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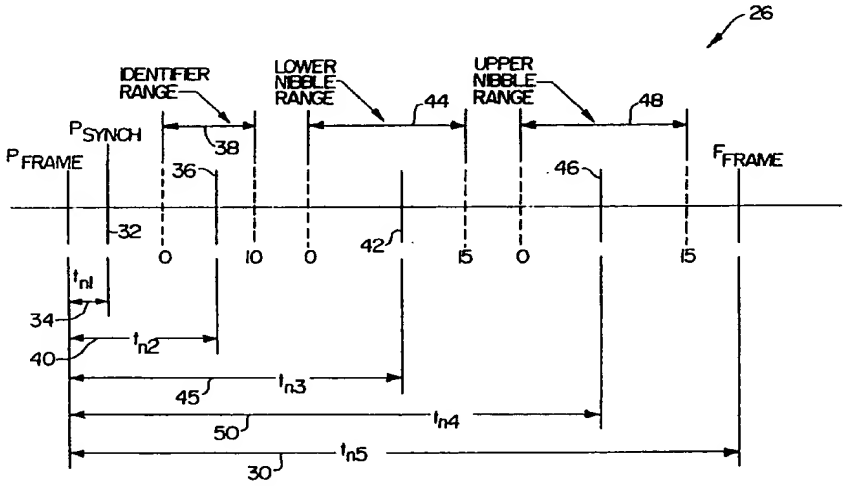

(57) Abstract

A method and apparatus are disclosed for telemetering both analog and digital data from an implantable medical device to an external receiver, such as between an implanted cardiac pacer and its external programming equipment. Analog data is first converted to digital format by an analog-to-digital converter, such that the transmission is digital data. A damped carrier at 175 kilohertz is pulse position modulated by the data. The modulation scheme defines a frame of slightly less than 2 milliseconds. The frame is divided into 64 individual time periods using a crystal clock. The data, along with synchronization and identification codes, are positioned into predefined ranges within each frame as measured by the individual time periods. The data is uniquely identified by the position of a burst of the carrier within the predefined range. This modulation scheme enables necessary data to be transmitted at sufficiently high rates with reduced power requirements thereby conserving the internal battery of the implantable device. This modulation scheme provides flexibility of use, for example, with complex medical devices where transmission of increased volumes of data is desirable, such as cardiac devices having dual-chamber or multisensor capabilities, and for controlling particular conditions, such as tachyarrhythmia.

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IMPROVED TELEMETRY FORMAT

BACKGROUND OF THE INVENTION

Field of the Invention.

The present invention generally relates to implantable medical devices, and more particularly, pertains to telemetry schemes for percutaneously transmitting analog and digital data from an implantable medical device.

Description of the Prior Art.

The earliest implantable medical devices were designed to operate in a single mode and with no direct percutaneous communication. Later it became clinically desirable to vary certain of the operating parameters and change modes of operation. This was accomplished through the use of programmers and other external devices which transferred commands percutaneously to the implanted medical device.

The communication between the implant and the external world was at first primarily indirect. The operation of an implantable cardiac pacer could be observed, for example, in the electrocardiogram of the patient. Soon it became known that data could be sent from the implanted cardiac pacer by modulating the stimulation pulses in some manner. This can only provide a low bandpass channel, of course, without interfering with the clinical application of the device. Change of the pacing rate to indicate battery condition was a commonly used application of this technique.

As implantable cardiac pacers became more complex, the desirability to transfer more data at higher speeds resulted in the percutaneous transmission of data using a radio frequency carrier. The data to be transmitted is of two basic types, namely, analog and digital. The analog information can include, for example, battery voltage, intracardiac electrocardiogram, sensor signals, output amplitude, output energy, output current, and lead impedance. The digital information can include, for

example, statistics on performance, markers, current values of programmable parameters, implant data, and patient and unit identifiers.

The earliest RF telemetry systems transmitted analog and digital information in separate formats, resulting in inefficient utilization of the available power/bandwidth. Also, these modulation schemes tended to be less than satisfactory in terms of battery consumption, and do not lend themselves to simultaneous transmission of differing data types.

Many types of RF telemetry systems are known to be used in connection with implantable medical devices, such as cardiac pacemakers. An example of a pulse interval modulation telemetry system used for transmitting analog and digital data, individually and serially, from an implanted pacemaker to a remote programmer is disclosed in U.S. Patent No. 4,556,063 issued to Thompson et al., herein incorporated by reference. An example of a modern pacemaker programmer for use with programmable cardiac pacemakers having RF telemetric capabilities is disclosed in U.S. Patent No. 4,550,370 issued to Baker, herein incorporated by reference. However, the telemetry format which is used under these systems, as well as other prior telemetry systems, have not been entirely adequate for reasons described above and a need for significant improvement has continued. As will become apparent from the following, the present invention satisfies that need.

SUMMARY OF THE INVENTION

The present invention percutaneously transmits all data from the implantable medical device in a digital format. It is pulse position modulated on an RF carrier. To accomplish this, the analog quantities must be converted to digital values either at the time of transmission, such as for real-time intracardiac electrocardiograms, or before storage in the memory of

the device, as in the case of historical values of pacing rate for subsequent transmission for trend analysis.

Whether the data to be sent is initially analog or digital, it is transmitted in the same format, i.e., as digital information. The RF carrier is pulse position modulated to conserve battery energy. In this manner, only a short burst of the carrier, e.g., one cycle, is actually needed to transmit a given unit of data. The time position of that burst relative to a synchronizing standard determines the value of the data unit transmitted.

To accomplish this pulse position modulation, a frame of about 2 milliseconds is defined. Within this frame are positioned a synchronizing burst, a frame identifier burst, and one or more data bursts. The synchronizing burst is positioned at a fixed position in the frame. The frame identifier and data are variables, such that the corresponding bursts occur within a range of time within the frame. The range in which a burst is found defines the nature or type of the variable. The position in the range defines the value of the variable.

Because all data transmission is in a digital format, great flexibility is achieved with regard to additional units of data for future applications. The use of the standardized format and capability of encoding more data into a single pulse also decreases the overall battery current requirements and serves to level the energy demand over time. Transmitting the analog data in digital form provides enhanced noise immunity and accuracy.

The transmission protocol provides data rates which are sufficient to transfer clinically useful EGM information in real time. Because each frame is independent, data quantities of varying precision can be transmitted using the same protocol. This modulation scheme provides flexibility of use, for example, with

complex medical devices where transmission of increased volumes of data is desirable in real time, such as cardiac devices having dual-chamber or multisensor capabilities, and for controlling particular conditions such as tachyarrhythmia.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be better understood, and its attendant advantages will be readily appreciated, by reference to the accompanying drawings when taken in consideration with the following detailed description, wherein:

FIG. 1 is a simplified schematic view of an implantable medical device employing the improved telemetry format of the present invention;

FIG. 2 is a conceptual view of one frame of the improved telemetry format of the present invention;

FIG. 3 is a view of the actual transmission pattern of two frames of the improved telemetry format;

FIG. 4 is a block diagram of a portion of an implantable medical device for implementation of the improved telemetry format;

FIG. 5 is a simplified flowchart showing the basic function of software to perform the telemetry uplink operation of the improved telemetry format;

FIG. 6 is a block diagram of the circuitry of the telemetry uplink hardware for implementing the improved telemetry format;

FIG. 7 is a block diagram of the circuitry of the telemetry timing for implementing the improved telemetry format; and

FIG. 8 is a schematic diagram of the driver circuitry for implementing the improved telemetry format.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A preferred embodiment of the present invention is disclosed relating to use of the improved telemetry format with an implantable cardiac pacer, which may be programmable. However, those of skill in the art will be readily able to adapt the teachings found herein to other implantable medical devices. It will also be understood by those of skill in the art that the telemetry format taught herein can be used for bi-directional communications between an implanted medical device and an external device.

FIG. 1 is a simplified schematic diagram of the present invention as employed in a cardiac pacing system. An implantable pulse generator **10** is implanted in the patient under the outer skin barrier **28**. Implantable pulse generator **10** is electrically coupled to the heart of the patient using at least one cardiac pacing lead **12** in a manner known in the art. Percutaneous telemetry data is transmitted from implantable pulse generator **10** by an RF uplink **26** utilizing the improved telemetry format to a receiving antenna **22**, which is coupled to a programmer **20** via a cable **24**. Receiving antenna **22** also contains a magnet which activates a reed switch in implantable pulse generator **10** as a safety feature, as taught in U.S. Patent No. 4,006,086 issued to Alferness et al., herein incorporated by reference. The telemetry data is demodulated and presented to the attending medical personnel by programmer **20**.

FIG. 2 is a schematic diagram of the protocol of RF uplink **26** using the improved telemetry format. The uplink uses a damped 175 kilohertz RF carrier which is pulse position modulated, as described in detail below. Shown at **30**, the basic timing unit of the format is a frame, having a duration of t_{ms}. It will be understood by those skilled in the art, however, that the present invention can be practiced using fixed-length frames

having periods of shorter or longer duration. In the preferred embodiment, the main timing source of implantable pulse generator 10 comprises a standard 32.768 kilohertz crystal clock which provides a basic clock cycle of 30.52 microseconds. Thus, a frame comprised of 64 clock cycles and extending over a fixed time interval of 1.953125 milliseconds is a convenient frame period, since such frame period is a binary multiple of the basic clock cycle.

A unique synchronizing signal is positioned within a first fixed range of each frame 30. This signal comprises a synchronizing RF pulse 32 which is located at a time t_{n1} within frame 30. To properly function as a synchronizing pulse, it must be located at a fixed point within the first fixed range of frame 30, as shown at 34.

A four-bit frame identifier code is positioned within a second fixed range of each frame 30, such second fixed range comprising an identifier range 38. Identifier range 38 uses a total of eleven basic clock cycles as shown. This identifier code comprises an identifier RF pulse 36 which is pulse position modulated within the identifier range 38. The position of identifier pulse 36 within identifier range 38 identifies the nature or type of data found within each frame 30 which is being transmitted, such as peak sense, peak pressure, sense threshold and others, as described in further detail below. Shown at 40, time interval t_{n2} thus uniquely represents the value of identifier pulse 36, which value in turn identifies the data type being transmitted within frame 30.

Each frame 30 transfers one eight-bit byte of data along with the identifier code. This data is divided into two portions comprised of four bits of data each. A first portion of this data, namely the four least significant bits of the data byte, is positioned within a third fixed range of frame 30, such third fixed range

comprising a lower nibble range 44. A second portion of this data, namely the four most significant bits of the data byte, is positioned within a fourth fixed range of frame 30, such fourth fixed range comprising an upper nibble range 48.

A lower nibble pulse 42 is pulse position modulated within lower nibble range 44, such that its value is uniquely identified by its location, such as at a time t_{n3} shown at 45. An upper nibble pulse 46 is also pulse position modulated within upper nibble range 48, such that its value is uniquely identified by its location, such as at a time t_{n4} shown at 50. Lower nibble range 44 and upper nibble range 48 each comprise sixteen basic clock cycles, permitting each of the sixteen unique values of the four-bit nibble to be specified. To prevent data overlap, suitable guardbands are positioned between each of the ranges within the frame to uniquely identify the synchronizing pulses, thereby avoiding undefined and erroneous data transmission.

FIG. 3 is a diagram of two frames of RF uplink 26, wherein a first frame corresponds to Word 1 shown at 70, and a second frame corresponds to Word 2 shown at 72. A count of clock cycles is indicated along an upper horizontal axis of this diagram for each frame. Each basic clock cycle has a duration of 30.52 microseconds. The first frame at 70 is initiated by an RF pulse 52. A synchronizing RF pulse 54 is shown uniquely identified as precisely four clock cycles later. Because the guardbands are all greater than four clock cycles, no combination of a frame identifier and data can appear as a synchronizing pulse. Synchronizing pulse 54 is used to provide frame synchronization between the transmitter (i.e., implantable pulse generator 10) and the receiver (i.e., programmer 20).

An identifier RF pulse 56 is located within identifier range 38, which range is defined as nine to

nineteen basic clock cycles from the beginning of frame **70**. In **Word 1**, for example, identifier pulse **56** is located at clock cycle nineteen. This identifies the frame as a particular type of data transfer, namely, "Sense Threshold" as indicated in Table 1 below.

TABLE 1

Position	Identification
9	Memory
10	Idle
11	EGM-1
12	Markers
13	Peak Sense
14	Pressure Waveform
15	Peak dp/dt
16	Peak Pressure
17	Delta Capacitor Voltage
18	Activity Counts
19	Sense Threshold

A lower nibble RF pulse **58** is located within lower nibble range **44**, which range is defined as twenty-four to thirty-nine basic clock cycles from the beginning of frame **70**. In **Word 1**, for example, lower nibble pulse **58** is located at clock cycle thirty-one, specifying a binary value of seven on a scale of zero to fifteen. An upper nibble RF pulse **60** is located at clock cycle fifty-eight within upper nibble range **48**, which range is defined as forty-four to fifty-nine basic clock cycles from the beginning of frame **70**, and is demodulated in similar fashion.

FIG. 4 is a block diagram of that portion of implantable pulse generator **10** which is associated with formatting and transmission of RF uplink **26**. Most of the

unique hardware which embodies the present invention is located on a single substrate, being a custom chip device indicated generally by arrow **105**. The remainder is microprocessor-based logic indicated generally by arrow **100**, comprising microprocessor **102**, random access memory (RAM) **104**, and parallel bus **106**. The function of microprocessor-based logic **100** is described in further detail below.

Chip **105** has an analog-to-digital (A/D) converter **108** which receives a number of analog inputs **110** from a multiplexer (not shown). A/D converter **108** permits data to be transferred via RF uplink **26** to be digitized as necessary, so that all data is transmitted in a standardized digital form.

Circuitry (CRC) for generating and analyzing the cyclic redundancy code used to forward error detect telemetry data transmitted over RF uplink **26** is indicated at **112**. In the preferred embodiment, it is also used for data received by implantable pulse generator **10** via a downlink (not shown). Circuitry (DMA) for providing direct memory access to RAM **104** is indicated at **114**, thus permitting multiple byte transfers without constant management by microprocessor **102**.

Key hardware used to implement RF uplink **26** comprises telemetry control and data buffer circuitry indicated generally within dashed lines at **121**, which circuitry includes data buffer **116** and telemetry control **120**, and up-link timing circuitry **118**. Data buffer **116** includes storage for twelve bits of data. This storage is partitioned into a four-bit section **119** for storage of the frame identifier code, and an eight-bit section **117** for storage of the lower nibble and upper nibble of a frame. Data buffer **116** thus stores all of the variables for one complete frame. Data buffer **116** is used to stage the variables for the frame which may be received from

RAM 104, A/D converter 108, CRC 112, or elsewhere along parallel bus 106.

Telemetry control 120 consists primarily of a telemetry status register. This register stores the telemetry commands and status as loaded by microprocessor 102. The contents of the register are thus used to gate the data at the proper time of the defined protocol.

Up-link timing 118 decodes the twelve bits of data stored in data buffer 116 to produce a set of timing signals which key bursts of RF energy at the appropriate times to pulse position modulate the 175 kilohertz carrier. Up-link timing 118 also keys bursts of RF energy at the fixed positions within the frame corresponding to the frame-initiating pulse and the synchronizing pulse.

FIG. 5 is a basic flowchart showing the overall function of the microprocessor-based logic 100. The role is essentially one of initiation of the transfer, rather than management of each detail of the transmission. Software associated with RF uplink 26 is started at element 130, usually by a down-linked command to transfer data.

Element 132 schedules the requested transmission via the up-link facilities. This scheduling prioritizes uplink transmission requests. Lower priority is given to continuous real time transfers, such as EGM and battery voltage, whereas higher priority is given to single occurrence transmissions of status information.

After scheduling, element 134 determines whether an uplink transmission is currently in progress. If an uplink transmission is in progress, element 132 re-schedules the request.

If an uplink transmission is not in progress after scheduling, element 136 initiates the uplink transmission by activating telemetry control 120. Exit is via element 138. While some additional management of the process is

required during the transmission, a description of such further details has been omitted, since it is not believed necessary to one skilled in the art to fully understand the present invention. As to the software associated with the uplink transmission, however, a source code listing of the pertinent sections of such software has been attached hereto as **Appendix A**, and is incorporated by reference herein.

FIG. 6 is a block diagram showing the major data and control signals of telemetry control and data buffer **121** (which includes data buffer **116** and telemetry control **120** shown in **FIG. 4**), and also of up-link timing **118**. A primary function of data buffer **116**, as indicated above, is the staging of the twelve variable bits of a given frame which correspond to a four-bit frame identifier **ID**, and dual-nibble data comprising a four-bit lower nibble **LN** and a four-bit upper nibble **UN**. The data is received over an eight-bit, parallel bus **159** and can be from any one of several sources. Control lines EGMDATA at **150**, PRSDATA at **151**, DLDMA at **153**, DMADS at **155**, LDANDAT at **156**, ENCRC at **161** and LDCRC at **171** specify the source. The output of A/D converter **108** of **FIG. 4** is presented separately to data buffer **116** as an eight-bit parallel transfer to ADC(0-7) at **154** (see **FIG. 6**). The output of CRC **112** is presented separately to data buffer **116** as an eight-bit parallel transfer to CRC(0-7) at **160**, since those devices are located on the same substrate.

Telemetry control **120** outputs a number of control signals, including EGMGAIN at **162**, RVPGAIN at **163**, EGMTELEN at **164**, ANULON at **165**, RAMULON at **166**, MEMEN at **167**, PRSTELEN at **168**, HDRCRCEN at **169** and EGMNPRS at **170**. These control outputs are used to enable and control inputs to data buffer **116**. The key outputs of telemetry control and data buffer **121** are TELRST at **182**, which resets up-link timing **118** and initiates the beginning of a frame, and a parallel data transfer at **184**, which

transfers the frame identifier ID, lower nibble LN and upper nibble UN to up-link timing 118.

Up-link timing 118 receives the frame-initiating control signal TELRST at 182 and the parallel data transfer (ID, LN and UN) at 184. A primary function of up-link timing 118 is to key the transmission of 175 kilohertz RF energy at the proper times to indicate start of frame, frame synchronization, frame identifier, lower nibble and upper nibble. Timing for this function is provided by the 32.768 kilohertz crystal clock to up-link timing 118 with clock signal XTAL at 186. An output TELCLK is provided at 188 which keys the actual burst of RF carrier at the proper times.

FIG. 7 is a block diagram of up-link timing 118. A frame timing generator 202 provides the desired timing for a frame according to clock input XTAL at 186, in a manner hereinabove explained. Thus, each frame is comprised of sixty-four basic clock cycles. The process is initiated by receipt of the frame-initiating control signal TELRST at 182, which enables uplink when in a low state and disables uplink when in a high state. The initial clock cycle of a frame contains a burst of RF energy which is keyed by control signal TELCLK at 188, which is also used to trigger the start of the data decoding by an uplink word multiplexer 200.

After the proper four-bit quantity is selected (i.e., frame identifier ID first, lower nibble LN next, and upper nibble UN last), a telemetry pulse timer 204 determines the appropriate timing for a burst to be provided to frame timing generator 202, and a corresponding burst of RF energy is keyed. Each of the four-bit quantities thus results in the keying of a burst of RF energy at the appropriate time within each frame.

FIG. 8 is a circuit diagram for the drive circuit for generating the RF carrier. A control signal TELCLK at 188 provides the timing information for keying the

carrier. A non-overlap generator 220 functions as a delay device to save current by preventing output transistors 230 and 232 from conducting simultaneously. Every transition of control signal TELCLK at 188 causes one transition by non-overlap generator 220. Inverters 222, 224, 226 and 228 are scaled to provide efficient switching with sufficient drive to the gates of transistors 230 and 232. Transistors 230 and 232 drive the signal off of chip 105 to ANTDR at 234 to an antenna circuit. A tuned circuit of discreet components, capacitor 236 and coil 238, are located external to chip 105. Each transition thus causes this tuned circuit to resonate at 175 kilohertz, thereby generating one uplink burst.

While the invention has been described above in connection with the particular embodiments and examples, one skilled in the art will appreciate that the invention is not necessarily so limited. It will thus be understood that numerous other embodiments, examples, uses and modifications of and departures from the teaching disclosed may be made as to various other systems for telemetering data to and from an implantable medical device, without departing from the scope of the present invention as claimed herein.

APPENDIX A

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                    10/12/89 08:11:23
********** R2 SYSTEM DATA AREA ***************** File: DATA.ASH          Page 9
********** $Revision:   3.0  $ *************
```

```
=0005          400  ext_tlm_active   EQU   5              ;Extended telemetry is active
=0006          401  mag_state        EQU   6              ;Magnet state, mode and rate are
               402                                        ;set to VOO_MODE and mag_rate following
               403                                        ;permanent programming.
=0007          404  rr_trans         EQU   7              ;Rate response transition
               405
=0080          406  TLM_NONMAG_MSK   EQU   10110000B     ;Mask to clear all telemetry
               407                                        ;flags except those associated
               408                                        ;with extended telemetry.
               409
               410  ;*****************************************************************
               411  ;*            tlm2_flags
               412  ;*****************************************************************
=0000          413  perm_prog_valid EQU   0              ;Valid Permanent programming
               414                                        ;occurred.
=0001          415  reset_inhibit   EQU   1              ;Reset inhibit featured
               416                                        ; - used in validate message
=0002          417  reset_pace_trigger EQU 2            ;Reset pace trigger featured
               418                                        ; - used in validate message
=0003          419  pk_sense_rqst    EQU   3            ;Single Peak sense measurement
               420                                        ;requested from programmer
=0004          421  uplnk_cnfrm      EQU   4            ;Uplink confirmation required
               422                                        ;on next event.
               423
               424
               425  ;*****************************************************************
               426  ;*            ULID
               427  ;*****************************************************************
=0005          428  CRC_error       EQU   5      ;CRC error indicator
=0006          429  uplink_memory   EQU   6      ;Uplink include memory block
=0007          430  uplink_CRC      EQU   7      ;Uplink includes CRC and header
               431
               432
               433  ;*****************************************************************
               434  ;*            Uplink_flags
               435  ;*****************************************************************
               436
=0000          437  uplnk_disabled EQU   0              ;Uplink is disabled
=0001          438  uplink_bsy     EQU   1              ;Uplink channel is busy
=0002          439  up_ram_pnd     EQU   2              ;RAM uplink pending
=0003          440  up_stat_pnd    EQU   3
=0004          441  intrrg_pnd     EQU   4              ;Interrogate data uplink pending
=0005          442  lcap_mrkr_pnd  EQU   5              ;Loss of capture marker uplink
               443                                     ;pending
=0006          444  mrkr_pnd       EQU   6              ;Event marker uplink pending
=0007          445  meas_pnd       EQU   7              ;Measured value uplink pending
               446
=0003          447  UPLNK_GN_SET   EQU   (2!^uplnk_disabled + 2!^uplink_bsy)
               448                                     ;Disable uplink and set busy
               449                                     ;for gain of signal
               450  ;*****************************************************************
               451  ;*            Uplink_stat equates
               452  ;*
               453  ;*****************************************************************
               454
=0004          455  page0_write     EQU   4              ;Write occured on page 0
=0005          456  magnet_applied  EQU   5              ;Reed switch is closed
=0006          457  checksum_error  EQU   6              ;Ram checksum error flag
=0007          458  POR_occured     EQU   7              ;POR flag
               459
=00F0          460  UPLNK_CLR_MSK   EQU   11110000B     ;Clear error bits in uplink
               461                                     ;stat
=00C0          462  UPLNK_POR_MSK   EQU   11000000B     ;Init mask used during POR
               463
               464  ;*****************************************************************
               465  ;*
               466  ;*            Downlink Control Byte equates
               467  ;*
```

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                    10/12/89 08:11:23
========== R2 SYSTEM DATA AREA ================= File: DATA.ASM              Page 12
========== $Revision:   3.0  $ =============
```

```
                    494  ;*************************************************************************
                    495  ;*
                    496  ;*            Telemetry equates
                    497  ;*
                    498  ;*************************************************************************
                    499
                    500  ;*************************************************************************
                    501  ;*            Marker values
                    502  ;*************************************************************************
                    503
=0066               504  MK_REFRAC_SENSE EQU     66H             ;Ventrical refractory sense mker
=00EE               505  MK_SENSE       EQU      0EEH            ;Ventrical sense marker
=00CC               506  MK_PACE        EQU      0CCH            ;Ventrical pace marker
=0077               507  MK_LOC         EQU      77H             ;Loss of capture marker
=00DD               508  MK_TRIGGERED   EQU      0DDH            ;Triggered pace marker
                    509
=0080               510  UP_CRC         EQU      80H             ;Uplink CRC val for ULID regist
=0000               511  UP_NOCRC       EQU      0               ;Uplink no CRC val for ULID reg
=0040               512  UP_MEM         EQU      40H             ;Uplink mem val for ULID regist
=0000               513  UP_NOMEM       EQU      0               ;Uplink no mem val for ULID
                    514                                          ;register
                    515
                    516  ;
                    517  ; ID code and CRC bits for uplink messages
                    518  ;
=0080               519  STATUS_ID      EQU      0 + UP_CRC + UP_NOMEM    ;Confirmation ID
=00C0               520  RAM_ID         EQU      0 + UP_CRC + UP_MEM      ;RAM uplink ID
=0043               521  MARKER_ID      EQU      3 + UP_NOCRC + UP_MEM    ;Marker channel ID
=0044               522  PKSENSE_ID     EQU      4 + UP_NOCRC + UP_MEM    ;Measure value IDs
=0046               523  PKDPDT_ID      EQU      6 + UP_NOCRC + UP_MEM
=0047               524  PKPRESS_ID     EQU      7 + UP_NOCRC + UP_MEM
=0048               525  DLTAVOLT_ID    EQU      8 + UP_NOCRC + UP_MEM
=0049               526  ACTCNT_ID      EQU      9 + UP_NOCRC + UP_MEM
=004A               527  SENSTHRS_ID    EQU      10 + UP_NOCRC + UP_MEM
                    528
                    529
                    530  ;*************************************************************************
                    531  ;*            Misc. telemetry equates
                    532  ;*************************************************************************
                    533
=00C3               534  ACCESS_CODE    EQU      0C3H            ;Telemetry access code for IPG
=00B3               535  RM_MODEL_ID    EQU      10110011B       ;IPG model I.D. value, model 8444
                    536
=0027               537  INTRRG_SIZ     EQU      39              ;Size of interrogate block
=0080               538  MAX_MEMREAD    EQU      128             ;Maximum memory block read size
                    539
=000F               540  PG0            EQU      0FH             ;Control byte Page 0 ID
=0001               541  PG7            EQU      1               ;Control byte Page 7 ID
=0002               542  PG8            EQU      2               ;Control byte Page 8 ID
=0004               543  PG10           EQU      4               ;Control byte Page 10 ID
                    544
=0003               545  DNLK_EXTRA_LEN EQU  3                   ;Message overhead (sub from
                    546                                          ;HW bytcount)
=0001               547  DNLK_CB_INDX   EQU  1                   ;First val field in downlink
                    548                                          ;message
                    549  ;
                    550  ; Emergency values
                    551  ;
=0041               552  EMG_PW         EQU      41H             ;Emergency Pulse Width (2ms)
=0018               553  EMG_AMP        EQU      18H             ;Emergency pulse amplitude
                    554                                          ;(6.0 Volts)
                    555
=0023               556  HIGH_RATE      EQU      23H             ;Highest rate that will allow
                    557                                          ;full RAM uplink (170ppm)
=001E               558  UPLINK_DELAY   EQU      1EH             ;Minimum time before next
                    559                                          ;scheduled event
                    560                                          ;needed for RAM uplink (300ms)
=0003               561  UPSTAT_DELAY   EQU      03H             ;Minimum time before next
```

```
264   ;*************************************************************************
265   ;*                      POR and Executive Macros                         *
266   ;*************************************************************************
267
268   ;@********************** CHECK_MARKER_UPLINK ***************************
269   ;@*                                                                      *
270   ;@*  Determine which marker code to uplink while in magnet mode or       *
271   ;@*  extended telemetry. If RAM uplink is in progress, the marker        *
272   ;@*  will be igonred.                                                    *
273   ;@*                                                                      *
274   ;@*  ENTRY CONDITIONS:                                                   *
275   ;@*    A pace/sense  or refractory sensed event is being processed.     *
276   ;@*    PACESTAT indicates if the event was refractory.                   *
277   ;@*                                                                      *
278   ;@*  EXIT CONDITIONS:                                                    *
279   ;@*    If maker channel is active and a valid marker is detected;        *
280   ;@*    a marker is uplinked.                                             *
281   ;@*                                                                      *
282   ;@*************************************************************************
283
284   ;-------------------------------------------------------------------------
285   ;@ MACRO CHECK_MARKER_UPLINK
286   ;@    BEGIN
287   ;@      (* check for marker uplink *)
288   ;@      IF (markers_active of mag_flags) THEN
289   ;@        BEGIN
290   ;-------------------------------------------------------------------------
291   ;CHECK_MARKER_UPLINK %MACRO
292   ;CMU_START
293   ;                                        ;Jump if marker channel NOT active
294   ;               BRCLR     markers_active,mag_flags,CMU_END
295   ;;-----------------------------------------------------------------------
296   ;;@          IF ((refractory_evnt of PACESTAT)
297   ;;@              AND (sensed_evnt of exec_flags)) THEN
298   ;;@            BEGIN     (* Refractory sensed event *)
299   ;;@              IF ((timeout_int - event_time) > 1) THEN
300   ;;@                x := MK_REFRAC_SENSE;
301   ;;@              ELSE
302   ;;@                EXIT;
303   ;;@            END;
304   ;;-----------------------------------------------------------------------
305   ;                                        ;Jump if NOT refractory sensed event
306   ;               BRCLR     refractory_evnt,PACESTAT,CMU_VVT
307   ;               BRCLR     sensed_evnt,exec_flags,CMU_VVT
308   ;               LDA       timeout_int
309   ;               SUB       event_time
310   ;               CMP       #1              ;Is there enough time for marker uplink?
311   ;               BLS       CMU_END         ; No, just exit
312   ;               LDX       #MK_REFRAC_SENSE
313   ;               BRA       CMU_UL          ; Yes, load marker and go uplink it
314   ;;-----------------------------------------------------------------------
315   ;;@          ELSE IF ((paced_evnt of exec_flags) AND
316   ;;@                   (sensed_evnt of exec_flags)) THEN
317   ;;@            BEGIN
318   ;;@              (* VVT mode, if triggered event send a triggered marker,
319   ;;@                 unless output is inhibited then send sense marker. *)
320   ;;@
321   ;;@              IF NOT(inhibit of tlm_flags) THEN
322   ;;@                x := MK_TRIGGERED;
323   ;;@              ELSE
324   ;;@                x := MK_SENSE;
325   ;;@            END;
326   ;;-----------------------------------------------------------------------
327   ;CMU_VVT
328   ;                                        ;Jump if NOT both pace and sense
329   ;               BRCLR     paced_evnt,exec_flags,CMU_CKPACE
330   ;               BRCLR     sensed_evnt,exec_flags,CMU_CKPACE
331   ;                                        ;Check for output inhibited
```

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                    10/12/89 08:12:32
========== R2 EXECUTIVE ==================== File: POREXEC.ASM          Page 9
========== $Revision:   3.0  $ ==========
```

```
332  ;               BRCLR     inhibit_enabled,tlm_flags,CMU_INHBT
333  ;               LDX       #MK_SENSE       ;If not, get sense marker
334  ;               BRA       CMU_UL          ;Go uplink it
335  ;CMU_INHBT
336  ;               LDX       #MK_TRIGGERED   ;Else get triggered marker
337  ;               BRA       CMU_UL          ;And send it
338  ;;-----------------------------------------------------------------------
339  ;;@          ELSE IF ((paced_evnt of exec_flags)
340  ;;@                   AND (NOT(inhibit of tlm_flags))) THEN
341  ;;@            (* If pacing is not inhibited, send a PACE marker.  *)
342  ;;@            x := MK_PACE;
343  ;;-----------------------------------------------------------------------
344  ;CMU_CKPACE
345  ;                                           ;Jump if NOT paced or if inhibited
346  ;               BRCLR     paced_evnt,exec_flags,CMU_CKSENSE
347  ;               BRSET     inhibit_enabled,tlm_flags,CMU_CKSENSE
348  ;               LDX       #MK_PACE        ;Else get marker code
349  ;               BRA       CMU_UL          ;And send it
350  ;;-----------------------------------------------------------------------
351  ;;@          ELSE IF (sensed_evnt of exec_flags) THEN
352  ;;@              x := MK_SENSE;
353  ;;@          ELSE
354  ;;@            (* No marker to uplink exit macro *)
355  ;;@            EXIT;
356  ;;-----------------------------------------------------------------------
357  ;CMU_CKSENSE
358  ;                                           ;Jump if not sensed event
359  ;               BRCLR     sensed_evnt,exec_flags,CMU_END
360  ;               LDX       #MK_SENSE       ;Else get marker value
361  ;;-----------------------------------------------------------------------
362  ;;@          (* Uplink marker code *)
363  ;;@          CALLM UPLINK_MARKER(x);
364  ;;@        END; (* marker channel active *)
365  ;;@
366  ;;-----------------------------------------------------------------------
367  ;CMU_UL
368  ;               UPLINK_MARKER               ;Ulink marker (value in x)
369  ;CMU_END
370  ;               %ENDM
371  ;-----------------------------------------------------------------------
372  ;@    END; (* CHECK_MARKER_UPLINK *)
373  ;-----------------------------------------------------------------------
374
375  $EJECT
```

```
480  ;@*********************** UPLINK_MARKER ******************************
481  ;@*                                                                  *
482  ;@*  This macro uplinks event markers if the channel is free.        *
483  ;@*                                                                  *
484  ;@*  ENTRY CONDITIONS:                                               *
485  ;@*    This routine expects x to contain the marker value to be      *
486  ;@*    uplinked.                                                     *
487  ;@*                                                                  *
488  ;@*  EXIT CONDITIONS:                                                *
489  ;@*    If the uplink channel is available it is captured and the     *
490  ;@*    marker is uplinked. If the channel is busy and there are      *
491  ;@*    no pending markers the marker is flagged pending for uplink   *
492  ;@*    at the end of the current uplink.                             *
493  ;@*                                                                  *
494  ;@*******************************************************************
495
496  ;UPLINK_MARKER %MACRO
497  ;
498  ;;-----------------------------------------------------------------
499  ;;@ MACRO UPLINK_MARKER;
500  ;;@   BEGIN
501  ;;@     disable interrupts;
502  ;;@     (* Check if uplink channel is available *)
503  ;;@     IF NOT(uplnk_disabled of uplink_flags) THEN
504  ;;@       BEGIN
505  ;;@         IF NOT(uplink_bsy of uplink_flags) THEN
506  ;;@           BEGIN
507  ;;@             (* If Uplink channel is free then uplink marker *)
508  ;;@             uplink_bsy of uplink_flags := TRUE;
509  ;;@             enable interrupts;
510  ;;@             marker_val := x;
511  ;;@             TELADHI := HIADDR(marker_val);
512  ;;@             TELADLO := LOADDR(marker_val);
513  ;;@             BYTCOUNT := 1;
514  ;;@             ULID := MARKER_ID;
515  ;;@             RAM_uplink of TELSTAT := TRUE;
516  ;;@           END;
517  ;;-----------------------------------------------------------------
518  ;UPM_START
519  ;               SEI                         ;Disable interrupts
520  ;                                           ;Jump if uplink disabled
521  ;               BRSET     uplnk_disabled,uplink_flags,UPLMDONE
522  ;UPLMARKER
523  ;                                           ;Jump if uplink BUSY
524  ;               BRSET     uplink_bsy,uplink_flags,UPL_BSY
525  ;;
526  ;;             Uplink NOT busy
527  ;;
528  ;                                           ;Flag uplink busy
529  ;               BSET      uplink_bsy,uplink_flags
530  ;               CLI                         ;Enable interrupts
531  ;               STX       marker_val        ;Put marker value in buffer
532  ;               LDA       #HIGH marker_val  ;Get MSB of buffer address
533  ;               STA       TELADHI           ;Write it to hardware
534  ;               LDA       #LOW marker_val   ;Get LSB of buffer address
535  ;               STA       TELADLO           ;Etc.
536  ;
537  ;               LDA       #1                ;Get output count
538  ;               STA       BYTCOUNT          ;Write to hardware count register
539  ;
540  ;               LDA       #MARKER_ID        ;Get ID code
541  ;               STA       ULID              ;Tell the hardware
542  ;                                           ;Start the uplink
543  ;               BSET      RAM_uplink,TELSTAT
544  ;               BRA       UPLMDONE
545  ;;-----------------------------------------------------------------
546  ;;@         ELSE
547  ;;@           BEGIN
```

```
548  ;;@            (* If no markers are pending the flag one pending *)
549  ;;@            mrkr_pnd of uplink_flags := TRUE;
550  ;;@            marker_val := x;
551  ;;@          END;
552  ;;@      END;
553  ;;@    enable interrupts;
554  ;;@
555  ;;-----------------------------------------------------------------
556  ;; Uplink BUSY
557  ;;
558  ;UPL_BSY
559  ;              BSET      mrkr_pnd,uplink_flags    ;Flag marker pending and
560  ;              STX       marker_val               ;store marker in the buffer
561  ;
562  ;UPLMDONE
563  ;              CLI                          ;Enable interrupts
564  ;              XENDM
565  ;-----------------------------------------------------------------
566  ;@   END;    (* UPLINK_MARKER *)
567  ;-----------------------------------------------------------------
568
569  $EJECT
```

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                    10/12/89 08:17:07
========== R2 PACE OR SENSE MODULE ============== File: POS.ASM                Page 38
========== $Revision:   3.0  $ ==============
```

```
1816  ;@********************* UPLINK_INTRRG ******************************
1817  ;@*                                                                 *
1818  ;@*  This macro uplinks the interrogate block of size INTRRG_SIZ and *
1819  ;@*  starting at the address pointed to by INTRRG_AD if the uplink   *
1820  ;@*  channel is free. Otherwise, if there is no RAM uplink, the      *
1821  ;@*  interrogate block is set pending and is scheduled via the next  *
1822  ;@*  TELBF interrupt, occurring when the uplink channel becomes      *
1823  ;@*  free. All other uplinks have to be disabled while checking the  *
1824  ;@*  uplink flags to avoid contention of the uplink channel.         *
1825  ;@*                                                                 *
1826  ;@*  ENTRY CONDITIONS:                                              *
1827  ;@*    None.                                                        *
1828  ;@*                                                                 *
1829  ;@*  EXIT CONDITIONS:                                               *
1830  ;@*    None.                                                        *
1831  ;@*                                                                 *
1832  ;@*******************************************************************
1833
1834  ;-------------------------------------------------------------------
1835  ;@MACRO UPLINK_INTRRG;
1836  ;@BEGIN
1837  ;@ (* Capture uplink channel - If busy set interrogate pending *)
1838  ;@  disable interrupts;
1839  ;@  IF NOT(uplnk_disabled of uplink_flags) THEN
1840  ;-------------------------------------------------------------------
1841  ;UPLINK_INTRRG %MACRO
1842  ;               SEI                     ;Dissable interrupts
1843  ;               BRSET     uplnk_disabled,uplink_flags,UI_END
1844  ;;-----------------------------------------------------------------
1845  ;;@    BEGIN
1846  ;;@      IF NOT(uplink_bsy of uplink_flags) THEN
1847  ;;@        BEGIN
1848  ;;@          uplink_bsy of uplink_flags := TRUE;
1849  ;;@          enable interrupts;
1850  ;;@          statbyt := uplnk_stat;
1851  ;;@          CALLM LOAD_INTRRG_UPLINK WITHIN R2LIB;
1852  ;;@          RAM_uplink of TELSTAT := TRUE;
1853  ;;@        END;
1854  ;;-----------------------------------------------------------------
1855  ;               BRSET     uplink_bsy,uplink_flags,UI_UBSY
1856  ;               BSET      uplink_bsy,uplink_flags
1857  ;               CLI                       ;Enable interrupts
1858  ;               LDA       uplnk_stat
1859  ;               STA       statbyt         ;Initialize the uplink status byte
1860  ;UI_LIU
1861  ;               LOAD_INTRRG_UPLINK
1862  ;UI_LIU_END
1863  ;               BSET      RAM_uplink,TELSTAT
1864  ;               BRA       UI_END
1865  ;;-----------------------------------------------------------------
1866  ;;@      ELSE
1867  ;;@        intrrg_pnd of uplink_flags := TRUE;
1868  ;;@    END;
1869  ;;-----------------------------------------------------------------
1870  ;UI_UBSY
1871  ;               BSET      intrrg_pnd,uplink_flags
1872  ;;-----------------------------------------------------------------
1873  ;;@    enable interrupts;
1874  ;;@
1875  ;;-----------------------------------------------------------------
1876  ;UI_END
1877  ;               CLI                       ;Enable interrupts
1878  ;               %ENDM
1879  ;-------------------------------------------------------------------
1880  ;@END;    (* UPLINK_INTRRG *)
1881  ;-------------------------------------------------------------------
1882
1883  $EJECT
```

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                    10/12/89 08:15:30
========== R2 LSCAP INTERRUPT MODULE ============ File: LOC.ASM          Page 10
========== $Revision:   3.0  $ ==============
```

```
409  ;@************************ UPLINK_LCAP_MARKER ************************
410  ;@*                                                                  *
411  ;@*  This macro uplinks loss of capture markers.                     *
412  ;@*                                                                  *
413  ;@*  ENTRY CONDITIONS:                                               *
414  ;@*    Under magnet operations, the LSCAPINT interrupt is used for   *
415  ;@*    the uplink of LOC markers if the channel is free.             *
416  ;@*                                                                  *
417  ;@*  EXIT CONDITIONS:                                                *
418  ;@*    None.                                                         *
419  ;@*                                                                  *
420  ;@******************************************************************
421
422  ;-------------------------------------------------------------------
423  ;@   MACRO UPLINK_LCAP_MARKER;
424  ;@   BEGIN
425  ;@
426  ;@     disable interrupts;
427  ;@     IF NOT (uplnk_disabled of uplink_flags) THEN
428  ;-------------------------------------------------------------------
429  ;UPLINK_LCAP_MARKER %MACRO
430  ;ULM_START
431  ;               SEI                         ;Disable interrupts
432  ;ULM_INT
433  ;                                           ;Jump if NOT (NOT uplnk_disabled)
434  ;               BRSET    uplnk_disabled,uplink_flags,ULM_DONE
435  ;
436  ;;-----------------------------------------------------------------
437  ;;@       BEGIN
438  ;;@         IF NOT(uplink_bsy of uplink_flags) THEN
439  ;;-----------------------------------------------------------------
440  ;
441  ;               BRSET     uplink_bsy,uplink_flags,ULM_LCP   ;Jump if uplink busy
442  ;
443  ;;-----------------------------------------------------------------
444  ;;@           BEGIN
445  ;;@             (* If Uplink channel is free then uplink marker *)
446  ;;@             uplink_bsy of uplink_flags := TRUE;
447  ;;@             enable interrupts;
448  ;;@             TELADHI := HIADDR(LCAP_MARKER);
449  ;;@             TELADLO := LOADDR(LCAP_MARKER);
450  ;;@             BYTCOUNT := 1;
451  ;;@             ULID := MARKER_ID;
452  ;;@             RAM_uplink of TELSTAT := TRUE;
453  ;;@           END;
454  ;;-----------------------------------------------------------------
455  ;               BSET      uplink_bsy,uplink_flags
456  ;               CLI                         ;Enable interrupts
457  ;               LDA       #HIGH lcap_marker ;Get address MSB
458  ;               STA       TELADHI           ;Write to controller register
459  ;
460  ;               LDA       #LOW lcap_marker ;Get address LSB
461  ;               STA       TELADLO           ;Write to controller
462  ;               LDA       #1                ;Get byte count
463  ;               STA       BYTCOUNT          ;Write to controller
464  ;               LDA       #MARKER_ID        ;Get ID
465  ;               STA       ULID              ;Write to controller
466  ;               BSET      RAM_uplink,TELSTAT ;Start uplink
467  ;               BRA       ULM_DONE          ;Thats all folks
468  ;
469  ;;-----------------------------------------------------------------
470  ;;@         ELSE
471  ;;@           BEGIN
472  ;;@             (* If no markers are pending the flag one pending *)
473  ;;@             lcap_mrkr_pnd of uplink_flags := TRUE;
474  ;;@           END;
475  ;;@       END;
476  ;;-----------------------------------------------------------------
```

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                                10/12/89 08:15:30
********** R2 LSCAP INTERRUPT MODULE ************ File: LOC.ASM                      Page 11
********** $Revision:   3.0  $ *************

477   ;ULM_LCP
478   ;                                          ;Jump if lcap marker pending
479   ;              BSET      lcap_mrkr_pnd,uplink_flags
480   ;
481   ;;-----------------------------------------------------------------------
482   ;;@     enable interrupts;
483   ;;-----------------------------------------------------------------------
484   ;ULM_DONE
485   ;              CLI                         ;Enable interrupts
486   ;
487   ;              XENDM
488
489   ;-----------------------------------------------------------------------
490   ;@
491   ;@   END;    (* UPLINK_LCAP_MARKER *)
492   ;@
493   ;-----------------------------------------------------------------------
494
495   $EJECT
```

```
187  ;*************************************************************************
188  ;*                      ADC Interrupt Macros                             *
189  ;*************************************************************************
190
191  ;@*********************** UPLINK_MEAS_VAL ***************************
192  ;@*                                                                     *
193  ;@*  This macro is used to uplink measured values.                      *
194  ;@*                                                                     *
195  ;@*  ENTRY CONDITIONS:                                                  *
196  ;@*    The array meas_val has been loaded with the appropriate          *
197  ;@*    data for uplink. The number of bytes for uplink is stored        *
198  ;@*    in the x register.                                               *
199  ;@*                                                                     *
200  ;@*  EXIT CONDITIONS:                                                   *
201  ;@*    If the uplink channel is free it is captured and the data        *
202  ;@*    in the meas_val buffer is uplinked. If the uplink channel        *
203  ;@*    is busy with a RAM uplink the measured values are                *
204  ;@*    discarded. Otherwise if the channel is busy the measured         *
205  ;@*    values are flagged as pending and uplinked on the next           *
206  ;@*    TELBF interrupt.                                                 *
207  ;@*                                                                     *
208  ;@*************************************************************************
209
210  ;-----------------------------------------------------------------------
211  ;@   MACRO UPLINK_MEAS_VAL(x);
212  ;@   BEGIN
213  ;@     IF NOT(uplnk_disabled of uplink_flags) THEN
214  ;-----------------------------------------------------------------------
215  ;UPLINK_MEAS_VAL %MACRO
216  ;UMV_START
217  ;               BRSET     uplnk_disabled,uplink_flags,UMV_END
218  ;
219  ;;---------------------------------------------------------------------
220  ;;@       BEGIN
221  ;;@         IF NOT(uplink_bsy of uplink_flags) THEN
222  ;;---------------------------------------------------------------------
223  ;
224  ;               BRSET     uplink_bsy,uplink_flags,UMV_SMV  ;Jump if uplink busy
225  ;
226  ;;---------------------------------------------------------------------
227  ;;@           BEGIN
228  ;;@            (* Uplink channel free uplink measured value buffer *)
229  ;;@             uplink_bsy of uplink_flags := TRUE;
230  ;;@             TELADHI := HIADDR(meas_val[0]);
231  ;;@             TELADLO := LOADDR(meas_val[0]);
232  ;;@             BYTCOUNT := x;
233  ;;@             ULID := meas_id;
234  ;;@             RAM_uplink of TELSTAT := TRUE;
235  ;;@           END;
236  ;;---------------------------------------------------------------------
237  ;               BSET      uplink_bsy,uplink_flags ;Set uplink busy
238  ;               LDA       #HIGH meas_val ;Get buffer address MSB
239  ;               STA       TELADHI        ;Write DMA address register
240  ;
241  ;               LDA       #LOW meas_val  ;Get buffer address LSB
242  ;               STA       TELADLO        ;etc.
243  ;               STX       BYTCOUNT       ;Write byte count
244  ;               LDA       meas_id        ;Get ID
245  ;               STA       ULID           ;Write to hardware
246  ;               BSET      RAM_uplink,TELSTAT ;Start uplink
247  ;               BRA       UMV_END        ;Go exit
248  ;
249  ;;---------------------------------------------------------------------
250  ;;@         ELSE  (* NOT uplink_bsy *)
251  ;;@           BEGIN
252  ;;@            (* Set measured value uplink pending *)
253  ;;@             meas_count := x;
254  ;;@             meas_pnd of uplink_flags := TRUE;
255  ;;@           END;
256  ;;@       END;
257  ;;---------------------------------------------------------------------
258  ;
```

```
259   ;UMV_SMV
260   ;               STX       meas_count      ;Save pending byte count
261   ;               BSET      meas_pnd,uplink_flags ;Show pending upling
262   ;               BRA       UMV_END         ;Thats all folks
263   ;UMV_END
264   ;               %ENDM
265   ;-------------------------------------------------------------------------
266   ;@   END;    (* UPLINK_MEAS_VAL *)
267   ;-------------------------------------------------------------------------
268
269   $EJECT
```

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                    1/18/90 10:35:56
========== R2 TELEMETRY MODULE ================== File: TLM.ASH          Page 7
========== $Revision:   3.3  $ ============
```

```
378  ;@********************************* TLM ***********************************
379  ;@*                                                                       *
380  ;@*    R2, Pacemaker Model 8444                                           *
381  ;@*    MODULE:      TLM                                                   *
382  ;@*                                                                       *
383  ;@*    The TLM module processes magnet mode operations while the reed     *
384  ;@*    switch is closed. These include the handling of the telemetry      *
385  ;@*    protocol, the TMT and lead test activation, the pulse pressure     *
386  ;@*    calculation for loss of capture markers detection. The             *
387  ;@*    telemetry protocol involves processing downlink and uplink         *
388  ;@*    messages. Downlink messages are validated before being acted       *
389  ;@*    upon. The uplink consists of confirmation and confirmation +       *
390  ;@*    replies to downlink requests.                                      *
391  ;@*                                                                       *
392  ;@*    Routines defined in this module include:                           *
393  ;@*                                                                       *
394  ;@*       Macros:                                                         *
395  ;@*          DO_MEMWRITE           - transfer downlink record to          *
396  ;@*                                  memory                               *
397  ;@*          EXEC_SPEC_FUNC        - decode and execute special           *
398  ;@*                                  function                             *
399  ;@*          EXEC_SPEC_REQ         - decode and execute special           *
400  ;@*                                  requests                             *
401  ;@*          PROCESS_MEMWRITE      - transfer downlink record to          *
402  ;@*                                  memory     and evaluate it           *
403  ;@*          PROCESS_MSG           - decode memory offsets                *
404  ;@*          SWITCH_TO_NON_MAGMODE - restore non_magnet mode              *
405  ;@*                                  operation                            *
406  ;@*          VALIDATE_MSG          - validate downlink message            *
407  ;@*                                                                       *
408  ;@*       Procedures:                                                     *
409  ;@*          None.                                                        *
410  ;@*                                                                       *
411  ;@*       Drivers:                                                        *
412  ;@*          GNLSINT_PROC          - gain or loss interrupt handler       *
413  ;@*          RDSWINT_PROC          - reed-switch interrupt handler        *
414  ;@*          TELBFINT_PROC         - telemetry buffer interrupt           *
415  ;@*                                  handler                              *
416  ;@*                                                                       *
417  ;@***************************************************************************
418
419
420               DEFSEG    TLM,CLASS=CODE
421               SEG       TLM
422
423  $SETLN(MACROS.INC);              %INCLUDE  "MACROS.INC"
```

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                                1/18/90 10:35:56
========== R2 TELEMETRY MODULE ================== File: TLM.ASM                        Page 8
========== $Revision:   3.3  $ ==============
```

```
                        424
                        425   $NOALLPUBLIC
                        426   $SETLN(EQUATES.INC);              %INCLUDE  "EQUATES.INC"
```

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                    1/18/90 10:35:56
========== R2 TELEMETRY MODULE ================== File: TLM.ASH          Page 33
========== $Revision:   3.3  $ ==============
```

```
1812   ;*************************************************************************
1813   ;*                        Telemetry Subroutines                          *
1814   ;*************************************************************************
1815
1816   $EJECT
```

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                                1/18/90 10:35:56
========== R2 TELEMETRY MODULE ================== File: TLM.ASM                      Page 34
========== $Revision:   3.3  $ =============
```

```
                    1817  ;*************************************************************************
                    1818  ;*                    Telemetry Interrupt Handlers                       *
                    1819  ;*************************************************************************
                    1820  ;@************************* GNSLINT_PROC ****************************
                    1821  ;@*                                                                     *
                    1822  ;@*  This procedure is the gain/loss interrupt handler and it is       *
                    1823  ;@*  non-preemptive. It is responsible for controlling the downlink     *
                    1824  ;@*  and disabling uplink. Whether the interrupt is do to a gain or a  *
                    1825  ;@*  loss of signal can be determined by reading a bit in the TELSTAT  *
                    1826  ;@*  register. At the beginning of a downlink all pending uplinks are  *
                    1827  ;@*  abandoned and the TELBF interrupt is masked out until the end of  *
                    1828  ;@*  downlink. In which case it is reenabled, after being first        *
                    1829  ;@*  cleared, in the case of downlink overrun. Downlink is then        *
                    1830  ;@*  disabled until just before the uplink response, either a status   *
                    1831  ;@*  uplink or a RAM uplink.                                           *
                    1832  ;@*                                                                     *
                    1833  ;@*  ENTRY CONDITIONS:                                                 *
                    1834  ;@*    No other interrupts are enabled at this point, ADC interrupts   *
                    1835  ;@*    are the only higher priority and they are ignored during        *
                    1836  ;@*    telemetry.                                                      *
                    1837  ;@*                                                                     *
                    1838  ;@*  EXIT CONDITIONS:                                                  *
                    1839  ;@*    None.                                                           *
                    1840  ;@*                                                                     *
                    1841  ;@*************************************************************************
                    1842
                    1843  ;-------------------------------------------------------------------
                    1844  ;@PROCEDURE GNLSINT_PROC;
                    1845  ;@BEGIN
                    1846  ;@
                    1847  ;@  (* Check if gain or loss of signal occurred. *)
                    1848  ;@  IF (downlnk_present of TELSTAT) THEN
                    1849  ;@    BEGIN
                    1850  ;@      (* Gain of downlink signal. Clear pending uplinks, disable
                    1851  ;@         uplink and TELBF interrupts, and clear any ADC and
                    1852  ;@         TELBFINT interrupts.                                    *)
                    1853  ;@      uplink_flags := UPLNK_GN_SET;
                    1854  ;@      IF (TMT of mag_flags) THEN
                    1855  ;@        reset_TMT of mag_flags := TRUE;
                    1856  ;@      TELBFINT of ipgstate_msk := TRUE;
                    1857  ;@      IRQREG := TELBFINT_MSK;
                    1858  ;@      ULID := 0;
                    1859  ;@
                    1860  ;@      (* If POS currently executing then postpone loss-of-signal
                    1861  ;@         processing until after POS is complete.                 *)
                    1862  ;@      IF ((sensed_evnt of exec_flags)
                    1863  ;@          OR (paced_evnt of exec_flags)) THEN
                    1864  ;@        GNLSINT of current_pri := TRUE;
                    1865  ;@    END;
                    1866  ;@
                    1867  ;-------------------------------------------------------------------
                    1868  GNLSINT_PROC
0000& 09 00* 1D     1869                BRCLR     downlnk_present,TELSTAT,GNLS_LOSS
0003& A6 03         1870                LDA       #UPLNK_GN_SET
0005& B7 00*        1871                STA       uplink_flags        ;Disable uplink
0007& 09 00* 02     1872                BRCLR     TMT,mag_flags,GNLS_NTMT
000A& 1A 00*        1873                BSET      reset_TMT,mag_flags ;Reset TMT if active
                    1874  GNLS_NTMT
000C& 14 00*        1875                BSET      TELBFINT,ipgstate_ms·    ;Mask TELBF interrupts
000E& AE 04         1876                LDX       #TELBFINT_MSK
0010& BF 00*        1877                STX       IRQREG                   ;Clear TELBF interrupts
0012& 4F            1878                CLRA
0013& B7 00*        1879                STA       ULID                     ;Clear ULID register
0015& B6 00*        1880                LDA       exec_flags               ;Is POS currently executing?
0017& A4 03         1881                AND       #((1 SHL sensed_evnt) + (1 SHL paced_evnt))
0019& 27 02         1882                BEQ       GNLS_NPOS                ; No, then exit
001B& 12 00*        1883                BSET      GNLSINT,current_pri      ; Yes, postpone loss-o-signal
                    1884                                                   ;      until after POS
```

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                                  1/18/90 10:35:56
========== R2 TELEMETRY MODULE ================== File: TLM.ASM                          Page 35
========== $Revision:   3.3  $ ============
```

```
                    1885  GNLS_NPOS
001D& CC 0384&      1886                JMP       GNLS_DONE
                    1887  ;-------------------------------------------------------------------
                    1888  ;a  ELSE IF (uplnk_disabled of uplink_flags) THEN
                    1889  ;a    BEGIN
                    1890  ;a      (* If the uplnk_disabled bit was not set then a downlink
                    1891  ;a         overrun has occured (gain of signal was missed) and
                    1892  ;a         downlink should be ignored!!                              *)
                    1893  ;a
                    1894  ;a      IF (reset_TMT of mag_flags) THEN
                    1895  ;a        CALL TMT_RESET WITHIN R2LIB;
                    1896  ;a
                    1897  ;a      uplnk_stat := (uplnk_stat AND UPLNK_CLR_MSK);
                    1898  ;a
                    1899  ;a      IF (TELBFINT of IRQREG) THEN
                    1900  ;a        BEGIN
                    1901  ;a          (* Downlink overflow - Flag error, uplink status,
                    1902  ;a             and clear TELBF interrupt *)
                    1903  ;a          IRQREG := TELBFINT_MSK;
                    1904  ;a          up_stat_pnd of uplink_flags := TRUE;
                    1905  ;a          uplnk_stat := uplnk_stat OR DNLK_OVF_ERR;
                    1906  ;a        END;
                    1907  ;-------------------------------------------------------------------
                    1908  GNLS_LOSS
0020& 00 00* 03     1909                BRSET     uplnk_disabled,uplink_flags,GNLS_LCONT
0023& CC 0384&      1910                JMP       GNLS_DONE
                    1911  GNLS_LCONT
0026& 0B 00* 03     1912                BRCLR     reset_TMT,mag_flags,GNLS_NTMTRST
0029& CD 0000*      1913                JSR       TMT_RESET      ;Go abort TMT sequence
                    1914  GNLS_NTMTRST
002C& B6 00*        1915                LDA       uplnk_stat
002E& A4 F0         1916                AND       #UPLNK_CLR_MSK
0030& B7 00*        1917                STA       uplnk_stat     ;Mask error bits in uplink status
0032& 05 00* 0D     1918                BRCLR     TELBFINT,IRQREG,GNLS_NOVF     ;Has downlink overflow occurred?
0035& AE 04         1919                LDX       #TELBFINT_MSK
0037& BF 00*        1920                STX       IRQREG                        ;Clear TELBF interrupts
0039& 16 00*        1921                BSET      up_stat_pnd,uplink_flags      ;Set status uplink pending
003B& AA 09         1922                ORA       #DNLK_OVF_ERR
003D& B7 00*        1923                STA       uplnk_stat                    ;Set and store Overflow error
003F& CC 0350&      1924                JMP       GNLS_UPLNK
                    1925  ;-------------------------------------------------------------------
                    1926  ;a      ELSE
                    1927  ;a        BEGIN
                    1928  ;a          (* No downlink overflow *)
                    1929  ;a          CALLM VALIDATE_MSG;
                    1930  ;a        END;
                    1931  ;-------------------------------------------------------------------
                    1932  GNLS_NOVF
                    1933                ;VALIDATE_MSG
                    1934  ;-------------------------------------------------------------------
                    1935  ;a      (* Request event time to be latched (write any value)
                    1936  ;a         NOTE: event time takes 0.244msec to be latched *)
                    1937  ;a      EVENTIME := 0;
                    1938  ;a
                    1939  ;a      IF ((up_RAM_pnd of uplink_flags)
                    1940  ;a          OR (intrrg_pnd of uplink_flags)) THEN
                    1941  ;a      BEGIN
                    1942  ;a        (* Only allow RAM uplink if the pacing interval is above
                    1943  ;a           HIGH_RATE, otherwise clear uplink status flag.          *)
                    1944  ;a        IF (timeout_int < HIGH_RATE) THEN
                    1945  ;a          BEGIN
                    1946  ;a            up_RAM_pnd of uplink_flags := FALSE;
                    1947  ;a            intrrg_pnd of uplink_flags := FALSE;
                    1948  ;a            up_stat_pnd of uplink_flags := TRUE;
                    1949  ;a          END;
                    1950  ;a        ELSE
                    1951  ;a          up_stat_pnd of uplink_flags := FALSE;
                    1952  ;a      END;
```

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                                1/18/90 10:35:56
========== R2 TELEMETRY MODULE ================== File: TLM.ASM                        Page 36
========== $Revision:   3.3  $ ==============
```

```
                    1953  ;---------------------------------------------------------------------
                    1954  GNLS_UPLNK
0350& B7 00*        1955                STA       EVENTIME        ;Latch event time count
                    1956  GNLS_UPEVNT
0352& B6 00*        1957                LDA       uplink_flags
0354& A4 14         1958                AND       #((1 SHL up_RAM_pnd) + (1 SHL intrrg_pnd))
0356& 27 11         1959                BEQ       GNLS_NRAMUP     ;Jump if no RAM of interrogate uplink
0358& C6 0000*      1960                LDA       timeout_int
035B& A1 23         1961                CMP       #HIGH_RATE      ;Is timeout less then upper rate limit?
035D& 24 08         1962                BHS       GNLS_RTLO       ; No, set uplink status flag false
035F& 15 00*        1963                BCLR      up_RAM_pnd,uplink_flags
0361& 19 00*        1964                BCLR      intrrg_pnd,uplink_flags
0363& 16 00*        1965                BSET      up_stat_pnd,uplink_flags
0365& 20 02         1966                BRA       GNLS_NRAMUP
                    1967  GNLS_RTLO
0367& 17 00*        1968                BCLR      up_stat_pnd,uplink_flags
                    1969  GNLS_NRAMUP
                    1970  ;---------------------------------------------------------------------
                    1971  ;@      (* If IPG in VVT mode switch to VVI mode until next event
                    1972  ;@         and scedule uplink if there is enough time.          *)
                    1973  ;@      triggered_mode of PACEMODE := FALSE;
                    1974  ;@      a := timeout_int - EVENTIME
                    1975  ;@      IF (((a > UPSTAT_DELAY) AND (up_stat_pnd of uplink_flags))
                    1976  ;@           OR (a > UPLINK_DELAY)) THEN
                    1977  ;@        CALL SCHEDULE_UPLINK WITHIN R2L18;
                    1978  ;@      ELSE
                    1979  ;@        uplnk_cnfrm of tlm2_flags := TRUE;
                    1980  ;@
                    1981  ;---------------------------------------------------------------------
0369& 15 00*        1982                BCLR      triggered_mode,PACEMODE  ;Set in non-VVT mode
0368& C6 0000*      1983                LDA       timeout_int
036E& B0 00*        1984                SUB       EVENTIME        ;Determine time remaining before next event
0370& A1 1E         1985                CMP       #UPLINK_DELAY   ;Enough time for block uplink?
0372& 22 07         1986                BHI       GNLS_SU         ; Yes, then schedule uplink
0374& 07 00* 09     1987                BRCLR     up_stat_pnd,uplink_flags,GNLS_NUPLNK
0377& A1 03         1988                CMP       #UPSTAT_DELAY   ;Enough time for status uplink?
0379& 23 05         1989                BLS       GNLS_NUPLNK     ; No, don't attempt uplink
                    1990  GNLS_SU
037B& CD 0000*      1991                JSR       SCHEDULE_UPLINK
037E& 20 02         1992                BRA       GNLS_CTLBF
                    1993  GNLS_NUPLNK
0380& 18 00*        1994                BSET      uplnk_cnfrm,tlm2_flags   ;Indicate uplink to follow next event
                    1995  ;---------------------------------------------------------------------
                    1996  ;@      (* Enable TELBF interrupts and clear ADC interrupts *)
                    1997  ;@      TELBFINT of ipgstate_msk := FALSE;
                    1998  ;@    END;
                    1999  ;@
                    2000  ;@  IRQREG := ADCINT_MSK;
                    2001  ;---------------------------------------------------------------------
                    2002  GNLS_CTLBF
0382& 15 00*        2003                BCLR      TELBFINT,ipgstate_msk
                    2004  GNLS_DONE
0384& A6 01         2005                LDA       #ADCINT_MSK
0386& B7 00*        2006                STA       IRQREG          ;Clear pending ADC interrupts
                    2007  GNLS_END
0388& 81            2008                RTS
                    2009  ;---------------------------------------------------------------------
                    2010  ;@END;    (* GNLSINT_PROC *)
                    2011  ;---------------------------------------------------------------------
                    2012
                    2013  $EJECT
```

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                                  1/18/90 10:35:56
========== R2 TELEMETRY MODULE ================== File: TLH.ASM                    Page 38
========== $Revision:   3.3  $ ============
```

```
                    2071  ;@************************ TELBFINT_PROC ******************************
                    2072  ;@*                                                                   *
                    2073  ;@*  This procedure is the telemetry buffer interrupt handler. It is  *
                    2074  ;@*  non-preemptive. It is responsible for scheduling pending uplinks *
                    2075  ;@*  (i.e. markers). If the last uplink was a RAM uplink, all pending *
                    2076  ;@*  uplinks are cancelled. Otherwise, if there is either a pending   *
                    2077  ;@*  interrogate block or measured value, they are uplinked.          *
                    2078  ;@*                                                                   *
                    2079  ;@*  ENTRY CONDITIONS:                                               *
                    2080  ;@*    No other interrupts are allowed during this routine, ADC must  *
                    2081  ;@*    be cleared if one occurred during uplink reschedule, and       *
                    2082  ;@*    processing of GAIN/LOSS must wait until after uplink TELBF     *
                    2083  ;@*    completes to insure that the uplink flags are not corrupted    *
                    2084  ;@*                                                                   *
                    2085  ;@*  EXIT CONDITIONS:                                                *
                    2086  ;@*    None.                                                          *
                    2087  ;@*                                                                   *
                    2088  ;@*********************************************************************
                    2089
                    2090  ;-------------------------------------------------------------------
                    2091  ;@PROCEDURE TELBFINT_PROC;
                    2092  ;@BEGIN
                    2093  ;@
                    2094  ;@  (* If RAM uplink complete clear all pending uplinks *)
                    2095  ;@  IF (uplnk_disabled of uplink_flags) THEN
                    2096  ;@    uplink_flags := 0;
                    2097  ;-------------------------------------------------------------------
0423& 01 00* 05     2098  TELBFINT_PROC
                    2099                BRCLR     uplnk_disabled,uplink_flags,TLBF_UPLNK
0426& 4F            2100                CLRA
0427& B7 00*        2101                STA       uplink_flags   ;Clear all pending uplinks
0429& 20 68         2102                BRA       TLBF_DONE
                    2103  ;-------------------------------------------------------------------
                    2104  ;@  ELSE
                    2105  ;@    BEGIN
                    2106  ;@      (* Previous uplink was not a RAM uplink, uplink pending *)
                    2107  ;@      IF (mrkr_pnd of uplink_flags) THEN
                    2108  ;@        BEGIN
                    2109  ;@          (* Marker from POS is pending *)
                    2110  ;@          mrkr_pnd of uplink_flags := FALSE;
                    2111  ;@          TELADHI := HIADDR(marker_val[0]);
                    2112  ;@          TELADLO := LOADDR(marker_val[0]);
                    2113  ;@          BYTCOUNT := marker_cnt;
                    2114  ;@          ULID := MARKER_ID;
                    2115  ;@          RAM_uplink of TELSTAT := TRUE;
                    2116  ;@        END;
                    2117  ;@
                    2118  ;-------------------------------------------------------------------
0428& 0D 00* 11     2119  TLBF_UPLNK
042E& 1D 00*        2120                BRCLR     mrkr_pnd,uplink_flags,TLBF_LCAP
0430& A6 ..X        2121                BCLR      mrkr_pnd,uplink_flags
                    2122                LDA       #HIGH marker_val    ;Load register with hi address of marker value
                                                                            address
0432& B7 00*        2123                STA       TELADHI
0434& A6 ..X        2124                LDA       #LOW marker_val     ;Load register with low address of marker value
                                                                            address
0436& B7 00*        2125                STA       TELADLO
0438& CE 0000*      2126                LDX       marker_cnt          ;Load x with byte count
043B& A6 43         2127                LDA       #MARKER_ID          ;Load a with marker identification byte
043D& 20 49         2128                BRA       TLBF_STRTU
                    2129  ;-------------------------------------------------------------------
                    2130  ;@      ELSE IF (lcap_mrkr_pnd of uplink_flags) THEN
                    2131  ;@        BEGIN
                    2132  ;@          (* Marker from loss of capture is pending *)
                    2133  ;@          lcap_mrkr_pnd of uplink_flags := FALSE;
                    2134  ;@          TELADHI := HIADDR(lcap_marker);
                    2135  ;@          TELADLO := LOADDR(lcap_marker);
                    2136  ;@          BYTCOUNT := 1;
```

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                                  1/18/90 10:35:56
========== R2 TELEMETRY MODULE ================== File: TLM.ASH                        Page 39
========== $Revision:   3.3  $ =============
```

```
                    2137  ;@          ULID := MARKER_ID;
                    2138  ;@          RAM_uplink of TELSTAT := TRUE;
                    2139  ;@        END;
                    2140  ;@          :
                    2141  ;-----------------------------------------------------------------
                    2142  TLBF_LCAP
043F& 08 00* 10     2143                BRCLR     lcap_mrkr_pnd,uplink_flags,TLBF_INTRRG
0442& 18 00*        2144                BCLR      lcap_mrkr_pnd,uplink_flags
0444& A6 ..X        2145                LDA       #HIGH lcap_marker   ;Load register with hi address of lcap marker v
                                                                          alue address
0446& B7 00*        2146                STA       TELADHI
0448& A6 ..X        2147                LDA       #LOW lcap_marker    ;Load register with low address byte of lcap ma
                                                                          rker value address
044A& B7 00*        2148                STA       TELADLO
044C& AE 01         2149                LDX       #1                  :Load x with byte count
044E& A6 43         2150                LDA       #MARKER_ID          ;Load a with marker identification byte
0450& 20 36         2151                BRA       TLBF_STRTU
                    2152  ;-----------------------------------------------------------------
                    2153  ;@      ELSE IF (intrrg_pnd of uplink_flags) THEN
                    2154  ;@        BEGIN
                    2155  ;@          intrrg_pnd of uplink_flags := FALSE;
                    2156  ;@          statbyt := uplnk_stat;
                    2157  ;@          CALLM LOAD_INTRRG_UPLINK WITHIN R2L18;
                    2158  ;@          RAM_uplink of TELSTAT := TRUE;
                    2159  ;@        END;
                    2160  ;-----------------------------------------------------------------
                    2161  TLBF_INTRRG
0452& 09 00* 20     2162                BRCLR     intrrg_pnd,uplink_flags,TLBF_MEAS
0455& 19 00*        2163                BCLR      intrrg_pnd,uplink_flags
0457& B6 00*        2164                LDA       uplnk_stat
0459& C7 0000*      2165                STA       statbyt         ;Update status byte
                    2166  TLBF_LDIN
                    2167                ;LOAD_INTRRG_UPLINK
                    2168  TLBF_LDIN_END
0471& 16 00*        2169                BSET      RAM_uplink,TELSTAT  ;Initiate uplink
0473& 20 1E         2170                BRA       TLBF_DONE
                    2171  ;-----------------------------------------------------------------
                    2172  ;@      ELSE IF (meas_pnd of uplink_flags) THEN
                    2173  ;@        BEGIN
                    2174  ;@          meas_pnd of uplink_flags := FALSE;
                    2175  ;@          TELADHI := HIADDR(meas_val[0]);
                    2176  ;@          TELADLO := LOADDR(meas_val[0]);
                    2177  ;@          BYTCOUNT := meas_count;
                    2178  ;@          ULID := meas_id;
                    2179  ;@          RAM_uplink of TELSTAT := TRUE;
                    2180  ;@        END;
                    2181  ;-----------------------------------------------------------------
                    2182  TLBF_MEAS
0475& 0F 00* 18     2183                BRCLR     meas_pnd,uplink_flags,TLBF_NUPLNK
0478& 1F 00*        2184                BCLR      meas_pnd,uplink_flags
047A& A6 ..X        2185                LDA       #HIGH meas_val      ;Load register with hi address of measured valu
                                                                          e address
047C& B7 00*        2186                STA       TELADHI
047E& A6 ..X        2187                LDA       #LOW meas_val       ;Load register with low address byte of measure
                                                                          d value address
0480& B7 00*        2188                STA       TELADLO
0482& CE 0000*      2189                LDX       meas_count          ;Load x with byte count
0485& C6 0000*      2190                LDA       meas_id             ;Load a with marker identification byte
                    2191  TLBF_STRTU
0488& BF 00*        2192                STX       BYTCOUNT            ;Store byte count
048A& B7 00*        2193                STA       ULID                ;Store marker identification byte
048C& 16 00*        2194                BSET      RAM_uplink,TELSTAT  ;Set the telemetry status byte and exit
048E& 20 03         2195                BRA       TLBF_DONE
                    2196  ;-----------------------------------------------------------------
                    2197  ;@      ELSE (* No pending uplinks *)
                    2198  ;@        uplink_flags := 0;
                    2199  ;@    END;
                    2200  ;@  (* Clear pending ADC interrupts *)
```

```
                    2201  ;@  IRQREG := ADCINT_MSK;
                    2202  ;@
                    2203  ;-------------------------------------------------------------------------
                    2204  TLBF_NUPLNK
0490& 4F            2205                CLRA
0491& B7 00*        2206                STA       uplink_flags    ;Clear uplink flags, no uplinks pending
                    2207  TLBF_DONE
0493& A6 01         2208                LDA       #ADCINT_MSK
0495& B7 00*        2209                STA       IRQREG          ;Clear pending ADC interrupts
                    2210  TLBF_END
0497& 81            2211                RTS
                    2212  ;-------------------------------------------------------------------------
                    2213  ;@END;    (* TELBFINT_PROC *)
                    2214  ;@
                    2215  ;-------------------------------------------------------------------------
                    2216                END
```

```
120  ;a********************* LOAD_INTRRG_UPLINK **************************
121  ;a*                                                                 *
122  ;a*  This macro loads the telemetry registers in preparation for an  *
123  ;a*  interrogate block uplink.                                       *
124  ;a*                                                                 *
125  ;a*  ENTRY CONDITIONS:                                              *
126  ;a*    Uplink data registers are ready to be loaded without conflict.*
127  ;a*                                                                 *
128  ;a*  EXIT CONDITIONS:                                               *
129  ;a*    The interrogate block the size of INTRRG_SIZ and starting at  *
130  ;a*    the address pointed to by INTRRG_AD is setup for uplink.      *
131  ;a*                                                                 *
132  ;a*******************************************************************
133
134  ;-------------------------------------------------------------------
135  ;a   MACRO LOAD_INTRRG_UPLINK;
136  ;a   BEGIN
137  ;a
138  ;a      (* Load interrogate status byte *)
139  ;a      intrrg_R2_stat := R2_stat;
140  ;a      (* Uplink channel assumed free and uplnk_disabled bit set *)
141  ;a      TELADHI := HIBYTE(INTRRG_AD);
142  ;a      TELADLO := LOWBYTE(INTRRG_AD);
143  ;a      BYTCOUNT := INTRRG_SIZ;
144  ;a      ULID := RAM_ID;
145  ;a
146  ;a   END;    (* LOAD_INTRRG_UPLINK *)
147  ;-------------------------------------------------------------------
148  ;LOAD_INTRRG_UPLINK %MACRO
149  ;               LDA     r2_stat         ;Get r2 status byte
150  ;               STA     intrrg_r2_stat ;put in interrogate status byte
151  ;               LDA     #HIGH INTRRG_AD ;Get address hi byte
152  ;               STA     TELADHI         ;Send it to the hardware
153  ;
154  ;               LDA     #LOW INTRRG_AD ;Get address lo byte
155  ;               STA     TELADLO         ;Send it to the hardware
156  ;
157  ;               LDA     #INTRRG_SIZ     ;Get byte count
158  ;               STA     BYTCOUNT        ;Write hardware register
159  ;               LDA     #RAM_ID         ;Get ID
160  ;               STA     ULID            ; etc. etc. etc.
161  ;               %ENDM
162
163  $EJECT
```

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                    1/08/90 11:38:20
========== R2 LIBRARY MODULE ================== File: R2LIB.ASM          Page 8
========== $Revision:   3.3  $ ============
```

```
164  ;@********************* LOAD_RAM_UPLINK ****************************
165  ;@*                                                                *
166  ;@*  This macro loads the telemetry registers in preparation for a *
167  ;@*  RAM block uplink.                                             *
168  ;@*                                                                *
169  ;@*  ENTRY CONDITIONS:                                             *
170  ;@*    Uplink data registers are ready to be loaded without conflict. *
171  ;@*                                                                *
172  ;@*  EXIT CONDITIONS:                                              *
173  ;@*    A RAM block of length indicated by P_rd_bytes starting at the *
174  ;@*    address indicated by P_rd_start is setup for uplink.        *
175  ;@*                                                                *
176  ;@****************************************************************
177
178  ;---------------------------------------------------------------------
179  ;@   MACRO LOAD_RAM_UPLINK;
180  ;@   BEGIN
181  ;@
182  ;@     (* Uplink channel assumed free and uplink_disabled bit set *)
183  ;@     intrrg_R2_stat := R2_stat;
184  ;@     TELADHI := HIBYTE(P_rd_start);
185  ;@     TELADLO := LOWBYTE(P_rd_start);
186  ;@     BYTCOUNT := P_rd_bytes;
187  ;@     ULID := RAM_ID;
188  ;@
189  ;@   END;    (* LOAD_RAM_UPLINK *)
190  ;---------------------------------------------------------------------
191  ;LOAD_RAM_UPLINK %MACRO
192  ;               LDA     r2_stat         ;Get r2 status byte
193  ;               STA     intrrg_r2_stat  ;put in interrogate status byte
194  ;               LDA     P_rd_start      ;Get address hi byte
195  ;               STA     TELADHI         ;Send it to the hardware
196  ;
197  ;               LDA     P_rd_start +1   ;Get address lo byte
198  ;               STA     TELADLO         ;Send it to the hardware
199  ;
200  ;               LDA     P_rd_bytes      ;Get byte count
201  ;               STA     BYTCOUNT        ;Write hardware register
202  ;               LDA     #RAM_ID         ;Get ID
203  ;               STA     ULID            ; etc. etc. etc.
204  ;               %ENDM
205
206
207  $RESETLN
239
240  $NOALLPUBLIC
241  $NOLIST                                 ;Don't List the equate file
```

```
                    1106  ;a********************* SCHEDULE_UPLINK *************************************
                    1107  ;a*                                                                         *
                    1108  ;a*  This procedure schedules uplink of RAM, interrogate block, or         *
                    1109  ;a*  status in this order of priority.                                      *
                    1110  ;a*                                                                         *
                    1111  ;a*  ENTRY CONDITIONS:                                                     *
                    1112  ;a*    No other interrupts are allowed during this routine, ADC           *
                    1113  ;a*    interrupts must be cleared if one occurred during uplink           *
                    1114  ;a*    scheduling. Processing of the GAIN/LOSS and TLBF interrupts         *
                    1115  ;a*    wait until after uplink is scheduled to ensure that the            *
                    1116  ;a*    uplink flags are not corrupted.                                    *
                    1117  ;a*                                                                         *
                    1118  ;a*  EXIT CONDITIONS:                                                      *
                    1119  ;a*    Either a RAM block, an Interrogate block, or a status              *
                    1120  ;a*    confirmation block are uplinked if any are pending.                *
                    1121  ;a*    Status is imbedded in a RAM or Interrogate block uplink.           *
                    1122  ;a*                                                                         *
                    1123  ;a*******************************************************************************
                    1124
                    1125  ;-------------------------------------------------------------------------
                    1126  ;a   PROCEDURE SCHEDULE_UPLINK;
                    1127  ;a   BEGIN
                    1128  ;a
                    1129  ;a     (* Load status byte for RAM uplink and the load telemetry
                    1130  ;a        registers for uplink. *)
                    1131  ;a     IF (up_RAM_pnd of uplink_flags) THEN
                    1132  ;a       BEGIN
                    1133  ;a         (* Load for Ram uplink *)
                    1134  ;a         CALLM LOAD_RAM_UPLINK;
                    1135  ;a         up_RAM_pnd of uplink_flags := FALSE;
                    1136  ;a       END;
                    1137  ;-------------------------------------------------------------------------
                    1138  SCHEDULE_UPLINK
                    1139                                              ;Jump if NOT RAM uplink
0180& 05 00* 1D     1140                  BRCLR     up_RAM_pnd,uplink_flags,SUP_INTRRG
                    1141  SU_LRU
                    1142                  ;LOAD_RAM_UPLINK
0183& B6 00*        1143                  LDA       r2_stat         ;Get r2 status byte
0185& C7 0000*      1144                  STA       intrrg_r2_stat  ;put in interrogate status byte
0188& C6 0000*      1145                  LDA       P_rd_start      ;Get address hi byte
018B& B7 00*        1146                  STA       TELADHI         ;Send it to the hardware
                    1147
018D& C6 ....X      1148                  LDA       P_rd_start +1   ;Get address lo byte
0190& B7 00*        1149                  STA       TELADLO         ;Send it to the hardware
                    1150
0192& C6 0000*      1151                  LDA       P_rd_bytes      ;Get byte count
0195& B7 00*        1152                  STA       BYTCOUNT        ;Write hardware register
0197& A6 C0         1153                  LDA       #RAM_ID         ;Get ID
0199& B7 00*        1154                  STA       ULID            ; etc. etc. etc.
                    1155  SU_LRU_END
019B& 15 00*        1156                  BCLR      up_RAM_pnd,uplink_flags ;Clear the pending flag
019D& CC 01D1&      1157                  JMP       SUP_STRT        ;Go start uplink
                    1158
                    1159  ;-------------------------------------------------------------------------
                    1160  ;a     ELSE IF (intrrg_pnd of uplink_flags) THEN
                    1161  ;a       BEGIN
                    1162  ;a         (* Load for interrogate block uplink *)
                    1163  ;a         CALLM LOAD_INTRRG_UPLINK WITHIN R2LIB;
                    1164  ;a         intrrg_pnd of uplink_flags := FALSE;
                    1165  ;a       END;
                    1166  ;-------------------------------------------------------------------------
                    1167  SUP_INTRRG
                    1168                                              ;Jump if NOT interrogate
01A0& 09 00* 1A     1169                  BRCLR     intrrg_pnd,uplink_flags,SUP_STAT
                    1170  SU_LIU
                    1171                  ;LOAD_INTRRG_UPLINK
01A3& B6 00*        1172                  LDA       r2_stat         ;Get r2 status byte
01A5& C7 0000*      1173                  STA       intrrg_r2_stat  ;put in interrogate status byte
```

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                                1/08/90 11:38:2C
========== R2 LIBRARY MODULE ================== File: R2LIB.ASM                        Page 3C
========== $Revision:   3.3  $ ==============
```

```
01A8& A6 ..X          1174                LDA     #HIGH INTRRG_AD ;Get address hi byte
01AA& B7 00*          1175                STA     TELADHI         ;Send it to the hardware
                      1176
01AC& A6 ..X          1177                LDA     #LOW INTRRG_AD ;Get address lo byte
01AE& B7 00*          1178                STA     TELADLO         ;Send it to the hardware
                      1179
01B0& A6 00*          1180                LDA     #INTRRG_SIZ     ;Get byte count
01B2& B7 00*          1181                STA     BYTCOUNT        ;Write hardware register
01B4& A6 C0           1182                LDA     #RAM_ID         ;Get ID
01B6& B7 00*          1183                STA     ULID            ; etc. etc. etc.
                      1184    SU_LIU_END
01B8& 19 00*          1185                BCLR    intrrg_pnd,uplink_flags ;Clear the flag
01BA& CC 01D1&        1186                JMP     SUP_STRT        ;Go start uplink
                      1187
                      1188    ;---------------------------------------------------------------------
                      1189    ;@     ELSE IF (up_stat_pnd of uplink_flags) THEN
                      1190    ;@       BEGIN
                      1191    ;@         (* Load for status ID byte for uplink *)
                      1192    ;@         ULID := STATUS_ID;
                      1193    ;@         up_stat_pnd of uplink_flags := FALSE;
                      1194    ;@       END;
                      1195    ;---------------------------------------------------------------------
                      1196    SUP_STAT
                      1197                                            ;Jump if NOT status ID byte
01BD& 07 00* 08       1198                BRCLR   up_stat_pnd,uplink_flags,SUP_NO_UP
01C0& A6 80           1199                LDA     #STATUS_ID
01C2& B7 00*          1200                STA     ULID            ;Write status ID to hardware
01C4& 17 00*          1201                BCLR    up_stat_pnd,uplink_flags ;Clear the flag
01C6& 20 09           1202                BRA     SUP_STRT        ;Go start Uplink
                      1203
                      1204    ;---------------------------------------------------------------------
                      1205    ;@     ELSE
                      1206    ;@       BEGIN
                      1207    ;@         (* No uplink scheduled reset telemetry and exit routine *)
                      1208    ;@         uplink_flags := 0;
                      1209    ;@         CALL SET_TLM_TYPE
                      1210    ;@         downlink_enable of TELSTAT := TRUE;
                      1211    ;@         EXIT;
                      1212    ;@       END;
                      1213    ;---------------------------------------------------------------------
                      1214    SUP_NO_UP
01C8& 3F 00*          1215                CLR     uplink_flags    ;Clear uplink_flags, no uplink
01CA& CD 01DE&        1216                JSR     SET_TLM_TYPE    ;Set telemetry type and enable downlink
01CD& 1A 00*          1217                BSET    downlink_enabled,TELSTAT
01CF& 20 0C           1218                BRA     SUP_END         ;Go exit
                      1219
                      1220    ;---------------------------------------------------------------------
                      1221    ;@     (* Set telemetry type start uplink and enable downlink *)
                      1222    ;@     statbyt := uplnk_stat;
                      1223    ;@     CALL SET_TLM_TYPE;
                      1224    ;@     downlink_enable of TELSTAT := TRUE;
                      1225    ;@     RAM_uplink of TELSTAT := TRUE;
                      1226    ;@
                      1227    ;---------------------------------------------------------------------
                      1228    SUP_STRT
01D1& B6 00*          1229                LDA     uplnk_stat      ;Get uplink status
01D3& C7 0000*        1230                STA     statbyt
01D6& CD 01DE&        1231                JSR     SET_TLM_TYPE    ;Set telemetry type
01D9& AA 28           1232                ORA     #(1 SHL RAM_uplink) + (1 SHL downlink_enabled)
01DB& B7 00*          1233                STA     TELSTAT         ;enable downlink and start uplink
                      1234    SUP_END
01DD& 81              1235                RTS                     ;Return to caller
                      1236    ;---------------------------------------------------------------------
                      1237    ;@   END; (* SCHEDULE_UPLINK *)
                      1238    ;---------------------------------------------------------------------
                      1239
                      1240    $EJECT
```

```
Avocet 6805 Assembler v2.20, #01002   Chip=146805                    1/08/90 11:38:20
========== R2 LIBRARY MODULE ================== File: R2LIB.ASM          Page 31
========== $Revision:   3.3  $ =============
```

```
                    1241  ;@************************ SET_TLM_TYPE ******************************
                    1242  ;@*                                                                  *
                    1243  ;@*  This procedure decodes the telemetry type in P_tlm_type and     *
                    1244  ;@*  sets up the hardware and marker channel accordingly.           *
                    1245  ;@*                                                                  *
                    1246  ;@*  ENTRY COND. :                                                   *
                    1247  ;@*    P_tlm_type contains the desired telemetry.                    *
                    1248  ;@*                                                                  *
                    1249  ;@*  EXIT COND. :                                                    *
                    1250  ;@*    The analog uplink telemetry is updated on the next frame.     *
                    1251  ;@*    Curr_tlm_type is written to PACESTAT and may not equal        *
                    1252  ;@*    P_tlm_type.                                                   *
                    1253  ;@*    a - contains the current value of the TELSTAT register.       *
                    1254  ;@*                                                                  *
                    1255  ;@******************************************************************
                    1256
                    1257  ;---------------------------------------------------------------------
                    1258  ;@   PROCEDURE SET_TLM_TYPE;
                    1259  ;@   BEGIN
                    1260  ;@
                    1261  ;@     (* test for markers uplink selected *)
                    1262  ;@     IF (marker_enabled of P_tlm_type := TRUE) THEN
                    1263  ;@       marker_active of msg_flags := TRUE;
                    1264  ;@     ELSE
                    1265  ;@       marker_active of msg_flags := FALSE;
                    1266  ;@
                    1267  ;---------------------------------------------------------------------
                    1268  SET_TLM_TYPE
01DE& C6 0000*      1269                LDA     P_tlm_type      ;Jump if idle markers set
01E1& A4 01         1270                AND     #(1 SHL marker_enabled)
01E3& 27 04         1271                BEQ     STT_ICLR
01E5& 1E 00*        1272                BSET    markers_active,msg_flags ;Show idle markers
01E7& 20 02         1273                BRA     STT_ADJ         ;Go adjust telem type
                    1274  STT_ICLR
01E9& 1F 00*        1275                BCLR    markers_active,msg_flags
                    1276
                    1277  ;---------------------------------------------------------------------
                    1278  ;@     (* adjust the telemetry type *)
                    1279  ;@     curr_tlm_type := (P_tlm_type AND TLM_TYPE_MSK) OR IDLE_UPLINK;
                    1280  ;@     TELSTAT := (TELSTAT AND TELSTAT_MSK) OR curr_tlm_type;
                    1281  ;@
                    1282  ;---------------------------------------------------------------------
                    1283  STT_ADJ
01EB& C6 0000*      1284                LDA     P_tlm_type      ;Get telemetry type
01EE& A4 C6         1285                AND     #TLM_TYPE_MSK   ;Isolate real time uplink type
01F0& AA 01         1286                ORA     #IDLE_UPLINK    ;Set uplink idle bit and save as current type
01F2& B7 00*        1287                STA     curr_tlm_type
01F4& B6 00*        1288                LDA     TELSTAT         ;Get current value of TELSTAT
01F6& A4 38         1289                AND     #TELSTAT_MSK    ; and mask changeable bits
01F8& BA 00*        1290                ORA     curr_tlm_type   ;Set new uplink type
01FA& B7 00*        1291                STA     TELSTAT         ;Write new TELSTAT and return
                    1292  STT_END
01FC& 81            1293                RTS
                    1294  ;---------------------------------------------------------------------
                    1295  ;@   END;    (* SET_TLM_TYPE *)
                    1296  ;---------------------------------------------------------------------
                    1297
                    1298  $EJECT
```

WHAT IS CLAIMED IS:

1. A method for transmitting data percutaneously between a medical device implanted within a human body and an external device, comprising the steps of:

(a) formatting the data to be transmitted by:

(1) establishing a frame having a fixed time interval;

(2) placing a unique synchronizing signal at a first fixed range within said frame;

(3) placing a frame identifier at a second fixed range within said frame; and

(4) placing said data at a third fixed range within said frame; and

(b) transmitting said formatted data between said implanted medical device and said external device.

2. A method according to claim 1, wherein said data is representative of more than one type of data, and wherein said frame identifier is indicative of the data type within said frame being transmitted.

3. A method according to claim 2, wherein said data is in digital format.

4. A method according to claim 3, wherein each of said steps (a)(2), (a)(3) and (a)(4) thereof further comprises generating a burst of radio frequency energy at a time within the corresponding fixed range appropriate to pulse position modulate said burst.

5. An apparatus for transmitting data percutaneously between an implantable medical device and an external device, comprising:

(a) frame defining means for defining a transmission frame of a fixed time interval;

(b) first means coupled to said frame defining means for transmitting a synchronizing signal within a first time range of said transmission frame;

(c) second means coupled to said frame defining means for transmitting a frame identifier within a second time range of said transmission frame; and

(d) third means coupled to said frame defining means for transmitting said data within a third time range of said transmission frame.

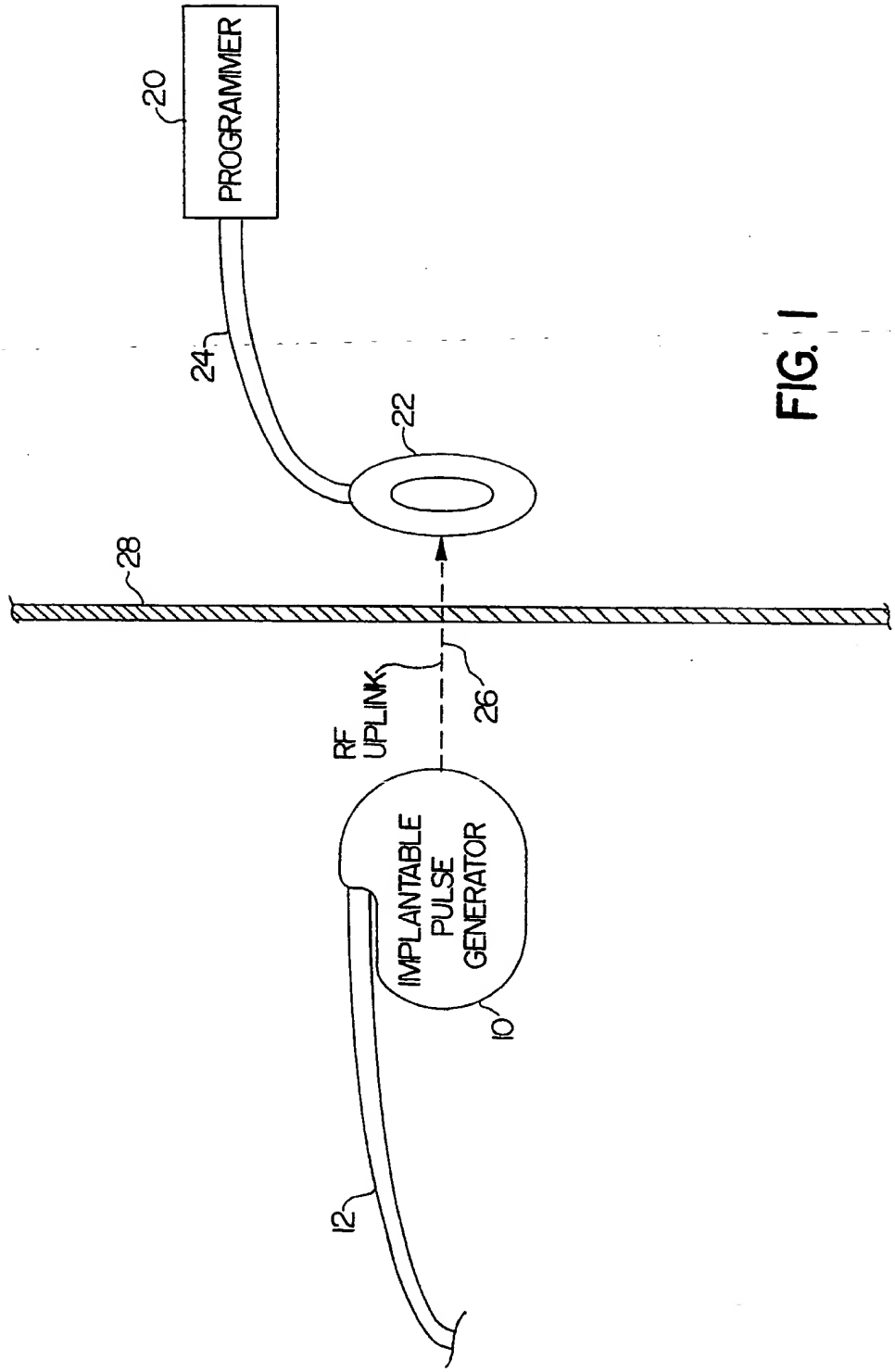

PROGRAMMER
20
24
22
28
RF
UPLINK
26
IMPLANTABLE
PULSE
GENERATOR
10
12

FIG. 1

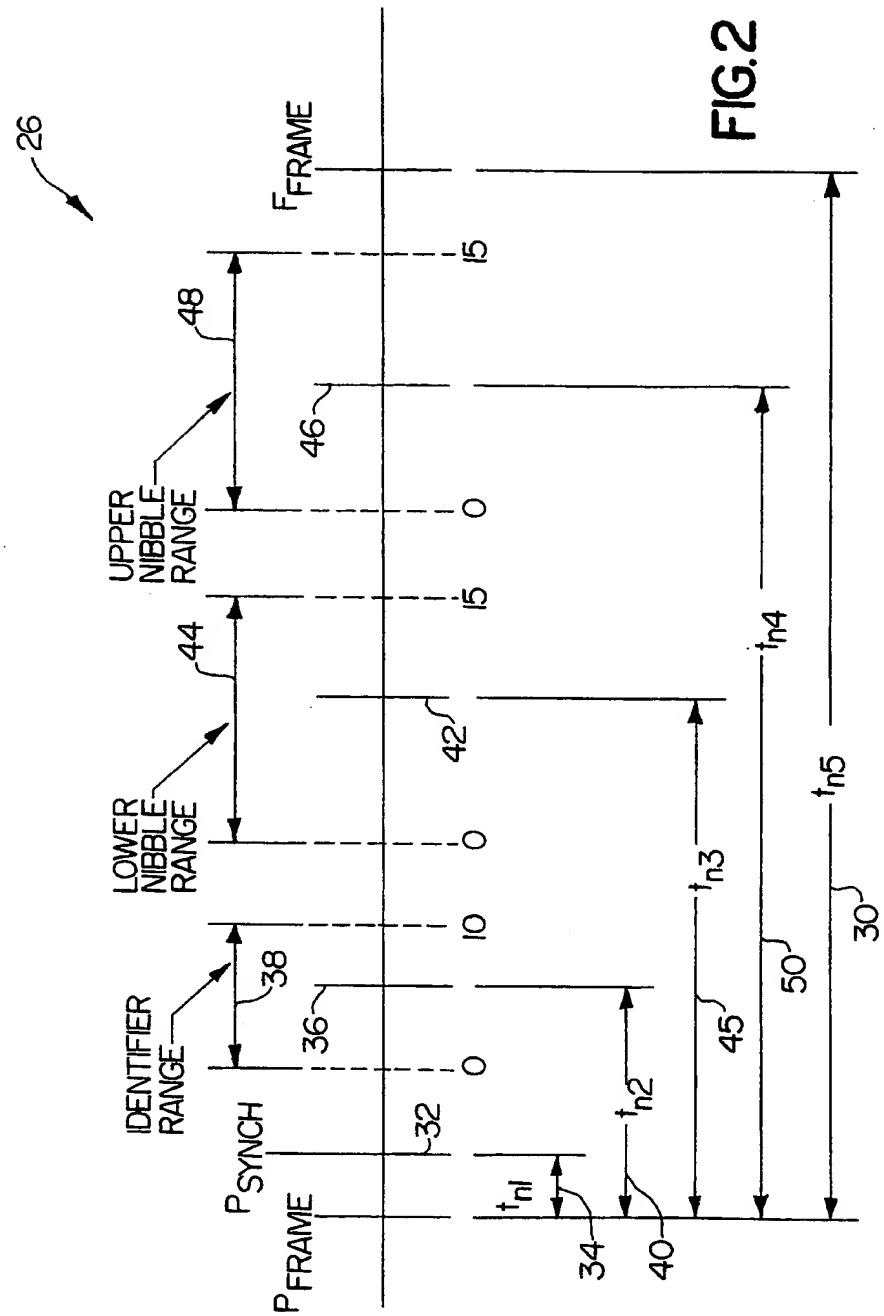
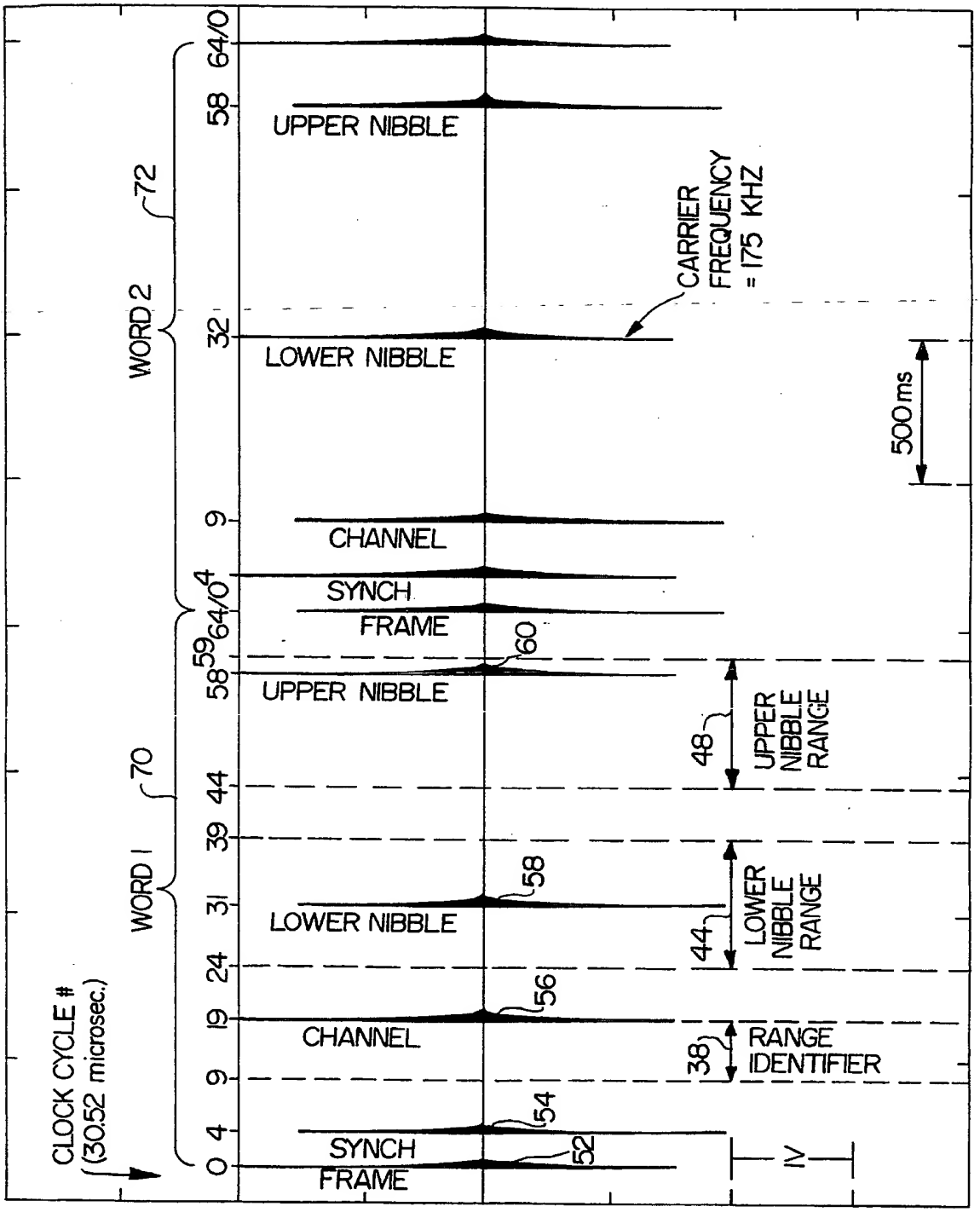

26
F FRAME
15
48
46
UPPER NIBBLE RANGE
0
15
44
42
LOWER NIBBLE RANGE
0
10
IDENTIFIER RANGE
38
36
0
32
P SYNCH
P FRAME
t n1
t n2
t n3
t n4
t n5
34
40
45
50
30

FIG.2

FIG. 3


64/0
58
UPPER NIBBLE
72
WORD 2
32
LOWER NIBBLE
CARRIER FREQUENCY = 175 KHZ
500 ms
9
CHANNEL
4
64/0
SYNCH
FRAME
59
60
58
UPPER NIBBLE
48
UPPER NIBBLE RANGE
70
WORD 1
44
39
31
58
LOWER NIBBLE
44
LOWER NIBBLE RANGE
24
56
19
CHANNEL
38
RANGE IDENTIFIER
9
54
4
SYNCH
52
0
FRAME
CLOCK CYCLE # (30.52 microsec.)
IV

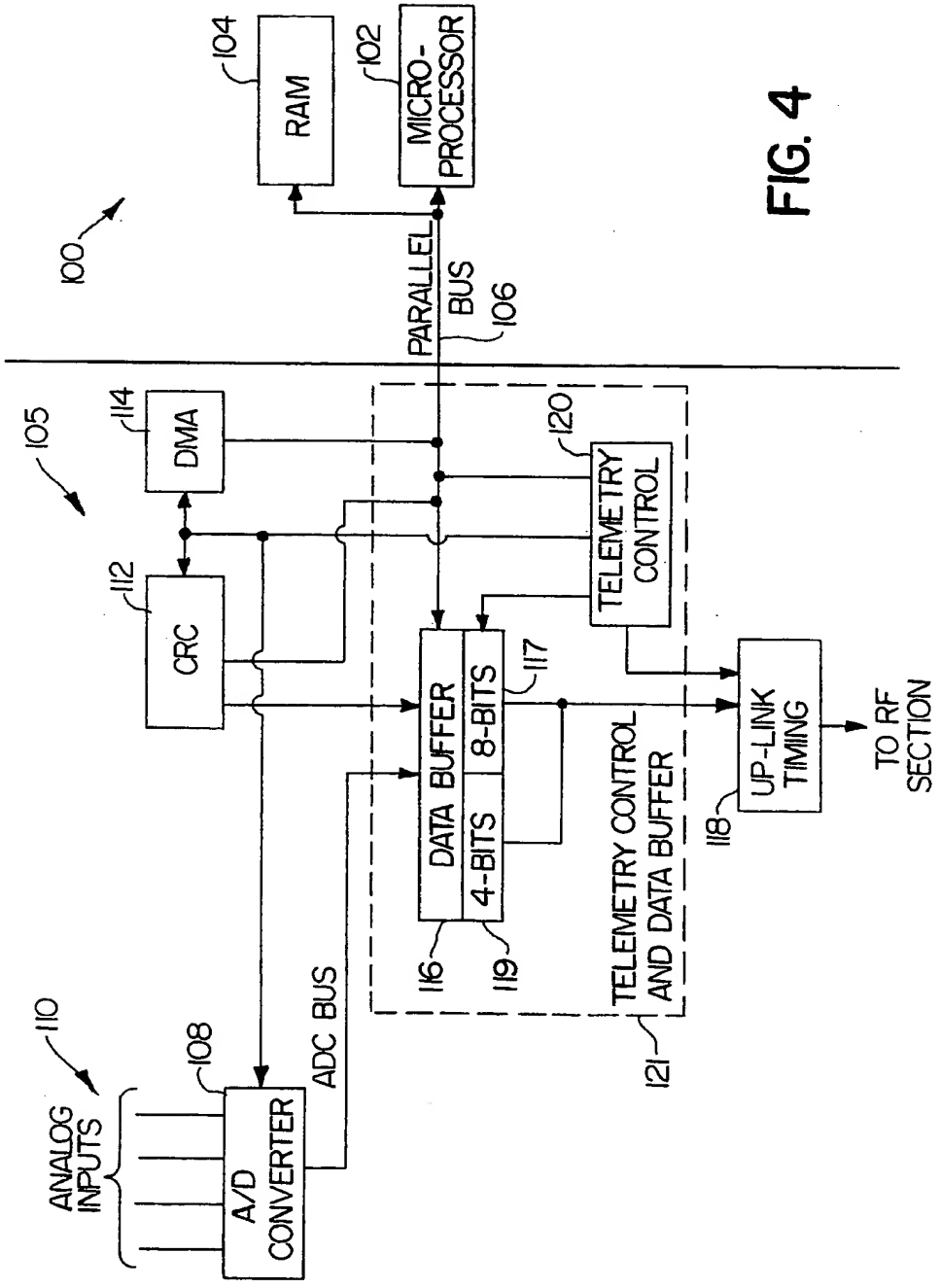

100
104
RAM
102
MICRO-PROCESSOR
PARALLEL BUS 106
105
114
DMA
112
CRC
120
TELEMETRY CONTROL
DATA BUFFER
8-BITS
4-BITS
117
116
119
TELEMETRY CONTROL AND DATA BUFFER
121
UP-LINK TIMING
118
TO RF SECTION
110
ANALOG INPUTS
108
A/D CONVERTER
ADC BUS

FIG. 4

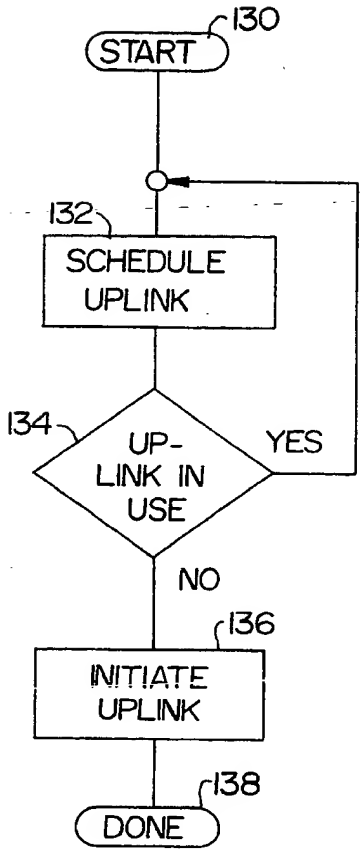

130
START
132
SCHEDULE UPLINK
134
UP-LINK IN USE
YES
NO
136
INITIATE UPLINK
138
DONE

FIG. 5

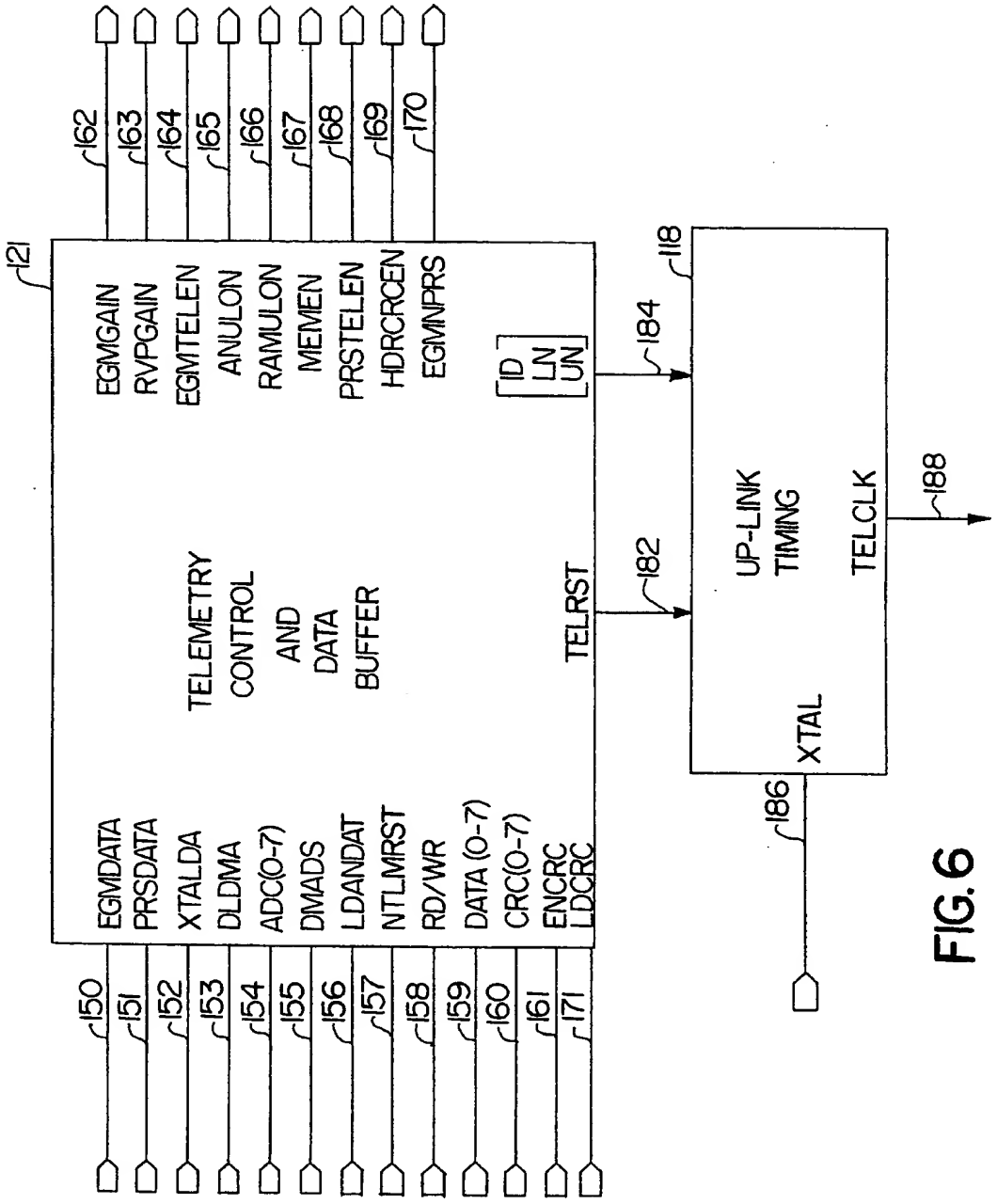
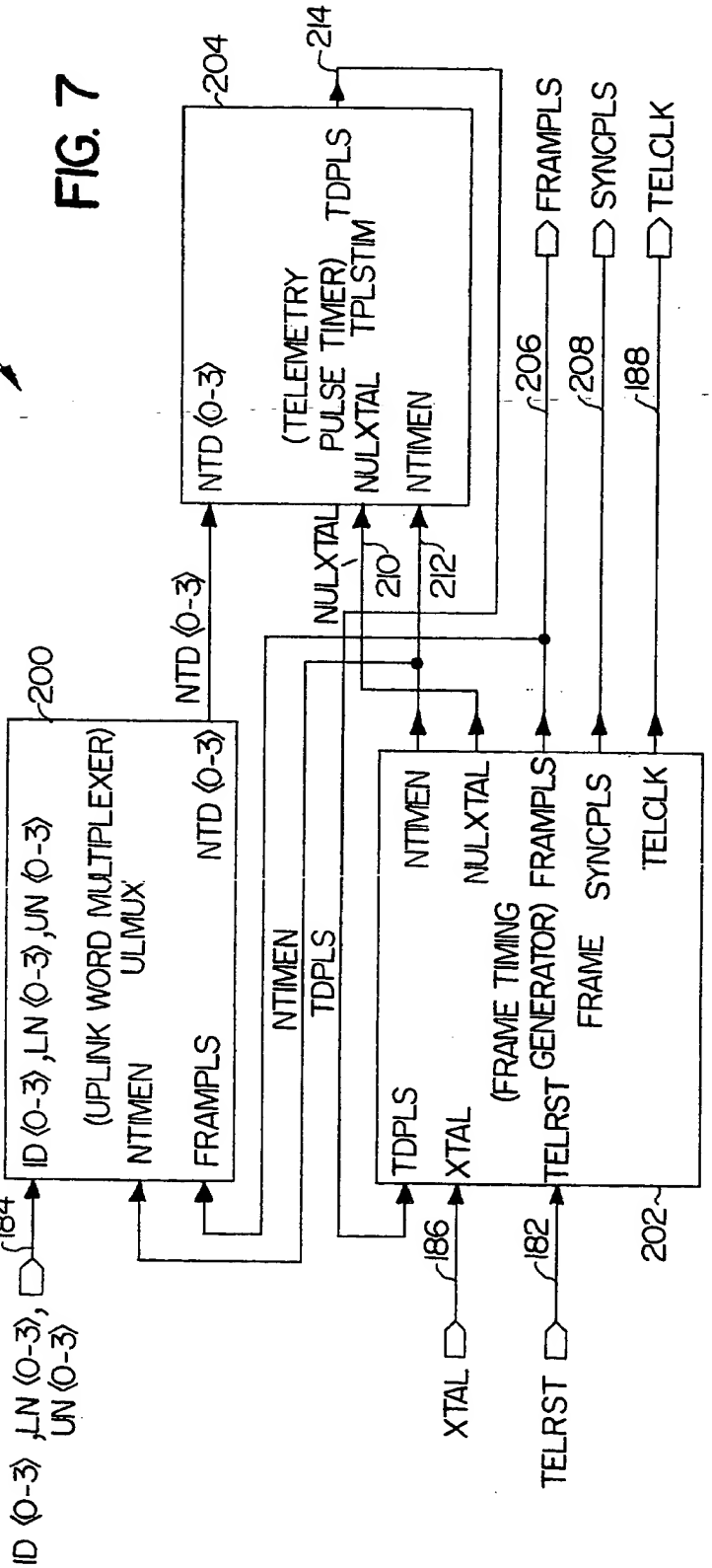

121
EGMDATA
PRSDATA
XTALDA
DLDMA
ADC(0-7)
DMADS
LDANDAT
NTLMRST
RD/WR
DATA (0-7)
CRC(0-7)
ENCRC
LDCRC
TELEMETRY CONTROL AND DATA BUFFER
EGMGAIN
RVPGAIN
EGMTELEN
ANULON
RAMULON
MEMEN
PRSTELEN
HDRCRCEN
EGMNPRS
ID
LN
UN
TELRST
118
UP-LINK TIMING
TELCLK
XTAL
150
151
152
153
154
155
156
157
158
159
160
161
171
162
163
164
165
166
167
168
169
170
182
184
186
188

FIG.6

FIG. 7


118
204
214
NTD ⟨0-3⟩
(TELEMETRY PULSE TIMER) TPLSTIM
NULXTAL
NTIMEN
TDPLS
206
208
188
FRAMPLS
SYNCPLS
TELCLK
NULXTAL
210
212
200
ID ⟨0-3⟩ ,LN ⟨0-3⟩ ,UN ⟨0-3⟩
(UPLINK WORD MULTIPLEXER) ULMUX
NTIMEN
FRAMPLS
NTD ⟨0-3⟩
NTIMEN
TDPLS
TDPLS
XTAL
NTIMEN
NULXTAL
(FRAME TIMING GENERATOR)
TELRST
FRAMPLS
FRAME SYNCPLS
TELCLK
184
186
182
202
ID ⟨0-3⟩ ,LN ⟨0-3⟩, UN ⟨0-3⟩
XTAL
TELRST

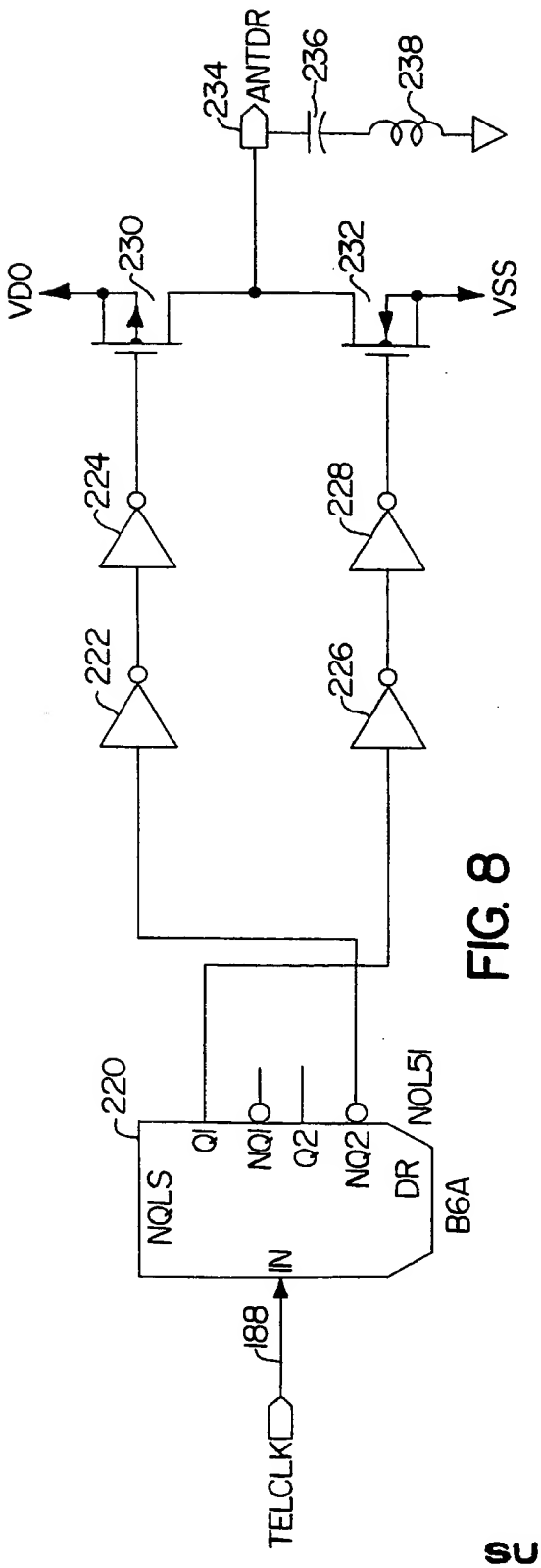

234
ANTDR
236
238
VDD
230
232
VSS
224
228
222
226
220
Q1
NQ1
Q2
NQ2
NOL51
NQLS
DR
B6A
IN
188
TELCLK

FIG. 8

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 91/00309

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: A 61 N 1/08, G 08 C 15/06

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	A 61 N, G 08 C, H 04 Q

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
Y	EP, A2, 0071131 (DEUTSCHE NEMECTRON GMBH) 9 February 1983, see page 5, line 24 - page 10, line 3; figures 1-4 --	1-5
Y	DE, C2, 2703700 (MULTIPLEX ELECTRONIK GMBH) 4 August 1983, see column 3, line 18 - line 37; figure 5; claim 1 --	1-5
Y	DE, A1, 3119119 (ROBERT BOSCH GMBH) 9 December 1982, see page 8, line 2 - line 18; figure 3 --	1-5

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
29th April 1991	28. 05. 91
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	M. PEIS M. Peis

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	US, A, 4556063 (D.L. THOMPSON ET AL) 3 December 1985, see column 1, line 10 - line 14; column 1, line 42 - line 47; column 3, line 35 - line 38; column 3, line 54 - line 58	1-5
A	ELECTRONICS, vol. 56, No. 5, March 1983,(NEW YORK, US) J.R. LINEBACK: "PACEMAKERS PICK UP PERFORMANCE WITH CUSTOM C-MOS CHIPS pages 47-48 ", see the whole document	1-5

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. PCT/US 91/00309

SA 44478

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 23/03/91
The European Patent office is in no way liable for theseparticulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A2- 0071131	09/02/83	AU-D-	8631682	03/02/83
		DE-A-	3130104	17/02/83
		JP-A-	58041570	10/03/83
		US-A-	4524774	25/06/85
DE-C2- 2703700	04/08/83	NONE		
DE-A1- 3119119	09/12/82	NONE		
US-A- 4556063	03/12/85	CA-A-	1183576	05/03/85
		CA-C-	1187140	14/05/85
		DE-A-	3139452	24/06/82
		FR-A-B-	2491659	09/04/82
		JP-A-	57089872	04/06/82
		NL-A-	8104534	03/05/82